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High-Speed Techniques

Direct-Projection Theater Television

Progress Committee Report

Magnetic Print-Through

Instructional Film Production

Production Principles Research

Audio-Visual Instruction Conference

TV Studio Lighting Report

THIS ISSUE IN TWO PARTS
Part I, May 1952 Journal
Part II, Membership Directory

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Techniques for Effective High-Speed Photography and Analysis

By RICHARD O. PAINTER

High-speed photographic methods used with commercially available moving film cameras are reviewed in this paper. Careful planning in regard to field size, reference lines, background and timing as well as other factors can contribute a great deal toward producing films which furnish a maximum of useful information. Special techniques employed in analysis can likewise simplify the task of data reduction. Some of these methods are illustrated.

HIGH-SPEED PHOTOGRAPHY has been used as an engineering tool by General Motors Proving Ground for over thirteen years. The experience gained during this period has been almost entirely with commercially available rotating-prism cameras covering the speed range from about 150 to 15,000 pictures per second. In a corporation as huge as General Motors and with such diversified products, the range of subjects to which high-speed photography might be applied is naturally very large. Much has been written concerning specialized techniques for high-speed photography such as schlieren, shadowgraph, X-ray and others. I shall not dwell on elaborate techniques such as these, but will relate some of the more common problems faced in the application of high-speed photography and how in our experience these problems have been met.

A 16mm camera with a maximum speed of about 2000 pictures per second was used for our early high-speed photographic work. Our lighting equipment consisted only of conventional photoflood lamps in aluminum reflectors. There was only one exposure procedure to follow when using higher camera speeds: "Open the lens fully, use as many lights as space permits, and bring them as close to the subject as possible." It was obvious that room for improvement existed in the lighting equipment. When projector spotlights first became available we were quick to make use of them. Overvoltage for these units was obtained through autotransformer boxes provided with a switch for selecting line voltage or high voltage, a tap switch for adjusting the high-voltage output in 10-v steps and a meter for reading the output voltage to the lights. These units and the projector spotlights were the solution to the lighting problem and are in fact still in use for most of our work. They are especially handy in compensating for line voltages that may be higher or lower than normal and are now provided with relays for shunting the line switch and throwing the lights on and off simultaneously with the camera operation. Experience has shown that the light intensity builds up rapidly enough to give adequate exposure from the very start of the film.

Presented on October 16, 1951, at the Society's Convention at Hollywood, Calif., by Richard O. Painter, General Motors Proving Ground, Milford, Mich.

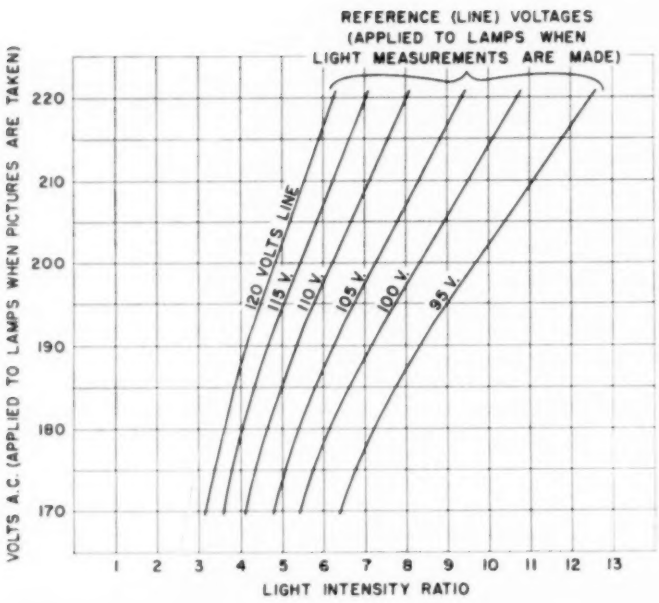

Fig. 1. Light intensity ratios for projector spotlights, G.E. Type Par/SP–150-w, 120-v.

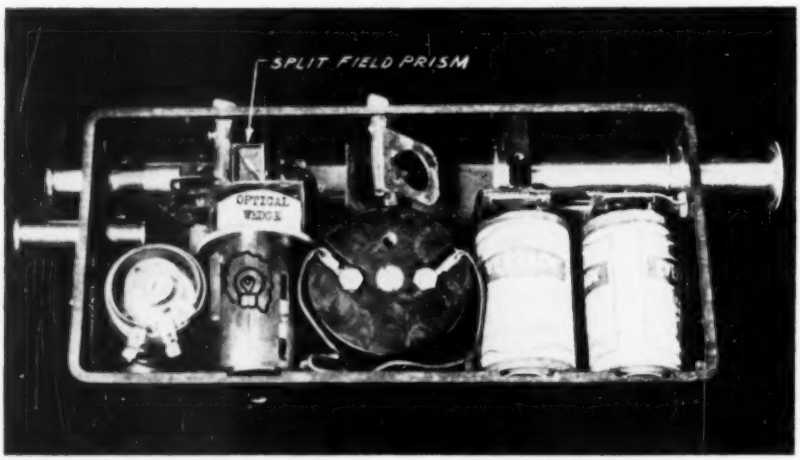

Fig. 2. Comparison-type brightness meter.

The same autotransformer boxes proved to be of help in the problem of measuring the high light intensities involved in high-speed photography. The ordinary exposure meter is not usually considered of much use in measuring high light intensities. However, with several supplementary devices, we have used such meters with much success. The meters are provided with perforated screens giving a multiplying factor of 5 on their indication. In addition, light measurement is carried out with line voltage applied to the lamps. This voltage is noted on the voltmeter mounted in the autotransformer boxes, and from the set of curves shown in Fig. 1 an additional multiplying factor is determined, to be applied to the light reading when the lamps are operated on higher voltage. This factor usually runs between 5 and 9 times and is dependent only upon lamp voltage at which light measurement is made and voltage at which the lamps are operated when the film is exposed. These ratios have been carefully determined by measurement with three different light-measuring devices and have been found to be very reliable. It can be seen that the employment of the exposure-meter filter and light-ratio method allows us to increase the light intensity which can be measured with conventional equipment by approximately 25 to 50 times. Light levels this high are suitable for high-speed photography up to the maximum speeds possible with rotating-prism cameras and allow plenty of margin so that smaller lens openings may be used.

Light measurement is frequently made on a substitute surface of paper having about 25 to 50% of the reflectivity of pure white. This is usually wise when the subject area is largely dark but does have small light-colored or highly reflective sections which must not be overexposed. Figure 2 is an interior view of a brightness meter which is very helpful when it becomes necessary to measure the light level on small areas or parts located in deep recesses where the conventional meter cannot be used. The subject is observed through the upper lefthand eyepiece and is viewed through a split-field prism having a hexagonal pattern in the center which receives its illumination from the light source below through an optical wedge or circular gradient filter. The subject is brought into focus with the lens tube at the right and with the current to the lamp set to the value indicated on the meter, the back of which may be seen at lower center, the optical wedge is rotated until brightness of the hexagonal pattern and brightness of the desired section of the field are matched. If the subject is too bright for a match, a multiplication of the range by a factor of 10,100 or 1000 is possible by inserting either one or both filters located at the upper center. The brightness level is read through the lower lefthand eyepiece from a scale surrounding the optical wedge. The range of this instrument is from 0.000005 to 110 c/sq in. The highest light level which can be measured with this instrument is therefore about 10 times the upper limit of the conventional meter and with the application of the light-ratio method previously mentioned, the measurement of any light level we may care to use or be able to attain appears to be possible. This meter was developed by Matthew Luckiesh and A. H. Taylor of the General Electric Lighting Research Laboratory. A brightness meter having somewhat similar features and manufactured by Salford Electrical Instruments, Ltd. of Great Britain was described in the New Products section, page 184, of the August 1951 *Journal*.

There is a strong tendency in high-speed photography to neglect the planning and preparation of the subject for the picture to be taken. We are often working with engineers from various divisions on mechanisms with which we are not familiar. It is wise in such a

Fig. 3. Commonly used lenses and extensions.

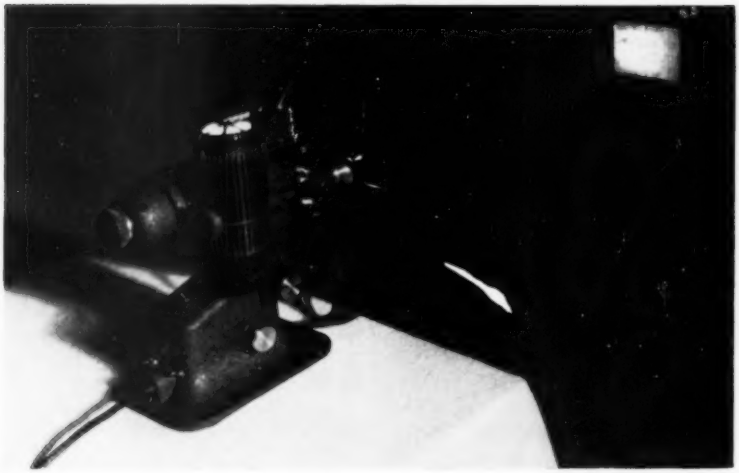

Fig. 4. Direct plotting of motions with time and motion study projector.

case to determine just what parts of the mechanism must be seen and what information will be needed from the film. If movements are to be measured, a scale is necessary and if only small movements are expected, every effort should be made to reduce the field covered by the camera. One basic rule we try to follow is to restrict the camera field to only that which is absolutely required to show the action. There are those who will try hard to have the entire engine included when only the action of a valve spring is under study. It should be obvious to even the most enthusiastic camera designer that movements of a few thousandths of an inch cannot be shown in a field five inches wide and yet just that sort of thing is expected by many people who want high-speed motion pictures taken.

To take care of the various field sizes which may be required when camera-to-subject distances are not a matter of choice, we use a variety of lenses and lens extensions. These are shown in Fig. 3. At the bottom of the picture are lens-plate shims of various thicknesses used to permit lens mounting at distances from film between normal and that possible with the shortest bayonet extension seen above to the right. In the lower righthand corner of the picture is a bayonet adapter used to mount the lenses shown on another camera not so equipped originally. Lenses shown are 254-mm, 105-mm, 2-in. and 35-mm. Although many other lenses are available for these cameras, we have found that those shown take care of a very high percentage of our work adequately. Above the lenses are extensions of various lengths, some variable, some fixed. Any extension up to about 12 in. can be obtained by using these tubes singly or in combination. The use of a long extension in connection with the 254-mm lens will provide as much as 5 times magnification of the image on 16mm film. Such magnifications have been useful in photographing contact action, small vibratory movements and spot and projection welding. When close-up photography is being performed, it is of course necessary to correct the lens aperture used for the amount of lens extension employed as this might otherwise reduce the exposure considerably.

When a subject is being prepared for high-speed photography it is well to plan beyond the basic uses to which the film is to be put and anticipate the need for additional information from the pictures. It is always wise to provide an accurate time base for the film either in the field covered, if frequent reference must be made to it, or at least along the edge of the film as furnished by the timing units provided for these cameras. Dimensional information should be given somewhere in the field of view by scales located close to the plane of motion or by marks placed a known distance apart on the subject. If the motion of a part of the subject relative to a stationary object or to another part is to be determined, a scale should be appropriately mounted to show this motion directly. Often the only requirement of a film is to show the character of a motion in comparing various conditions; however, the provision of scales and timing for more specific evaluation is usually good foresight.

Figure 4 shows a time and motion study projector being used to plot the action of a high-speed camera subject. Such projectors designed for time and motion study of production operations by methods-engineering and standards groups have features which suit the job of analyzing our films very well. This machine projects a very bright clear single frame and has a hand crank which moves the film four frames per turn. In addition a frame counter is provided which can be reset to zero on any frame desired. This makes plotting on any desired picture interval easy, allows a precise accounting of motion relative to frame count and simplifies the de-

Fig. 5. Camera and mirror mounted to photograph suspension action on car.

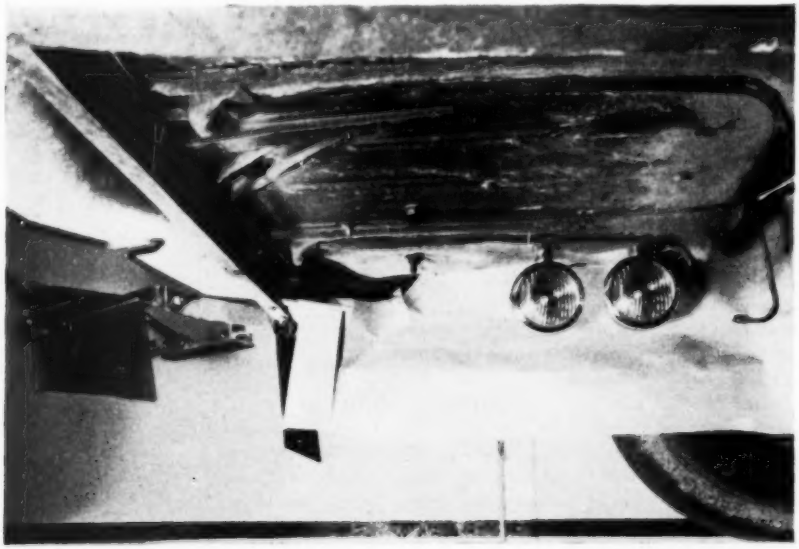

Fig. 6. Underside of car showing mirror and lights used to photograph suspension action.

termination of picture-taking rate. This projector also features governor-controlled projection rate which is adjustable from 800 to 1200 pictures per minute. This feature makes it possible to quickly make time measurements directly from the film. This is done by adjusting the projector speed so that the elapsed time between timing marks, or an interval on the time scale as checked by a stopwatch, is a convenient multiple of the actual time represented. It is then a simple matter to use the stopwatch to check time in the motion of the subject and divide this by the predetermined multiple to get true time. Reasonable accuracy may be obtained in this manner provided reference is made to the time base along the same section of film as is being studied.

The arrangement in Fig. 4 is used to plot subject motions directly on graph paper. The projection distance is adjusted to make the dimensions scale 1:1 or some convenient ratio. In this case all motions of interest were horizontal and timing marks were provided on the film at 0.001-sec intervals. Horizontal motions were plotted against time on the vertical scale and the projector elevating mechanism was used to position the picture for plotting while a stationary reference line on the subject was used in following one of the vertical chart lines.

The photography of moving vehicles and various components on them such as suspension members, accounts for about 20% of our film footage. Figure 5 shows a camera mounted in the trunk of a car using a mirror to obtain a view of the rear spring and shock absorber. Mirrors can be very useful in getting views from otherwise difficult angles. Mirror shake usually gives no trouble since at the frame speeds employed it results in only a slow drift in the projected picture. Figure 6 is a view underneath the same car with the gasoline tank removed to allow a better view of the subject. The lights used in this case are fog-lamp units having an elongated beam of light quite suitable for illuminating the spring. Batteries were used to power the lights and an overvoltage of about 75% was applied to increase the illumination intensity. Camera power was likewise derived from batteries, although a motor generator a-c source is frequently used for this purpose.

Another method of photographing moving vehicles which we use involves setting up the camera alongside the roadway and either following the vehicle by panning the camera or allowing the vehicle to pass through the field of the camera. Still another method employed with success involves a car to carry the camera and run alongside the subject vehicle while the picture is taken. The camera is sighted on the subject through the use of a simple sighting arrangement and the camera operation is initiated when the subject is properly centered in the sight. This method of taking moving-vehicle films has been especially successful and since the time involved in running the film through the camera is only a few seconds no great difficulty exists in keeping the subject in view once it is lined up.

At one time it was desired to photograph the action of a tire tread as a car was accelerated from a standstill. The best view and perhaps the only view possible could be taken from just one position, underneath a plate-glass surface on which the tire rested. Figure 7 shows the tire on a heavy piece of plate glass. The camera setup below the plate glass is shown in Fig. 8. Although the coefficient of friction between plate glass and rubber was naturally somewhat different from that between normal road surfaces and rubber, the general behavior of the tire tread was quite informative.

The application of high-speed photography to the study of combustion in a gasoline engine is by no means new; however, steady progress has been made

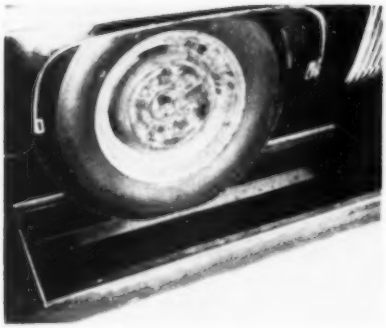

Fig. 7. Wheel on plate glass for tire tread photography.

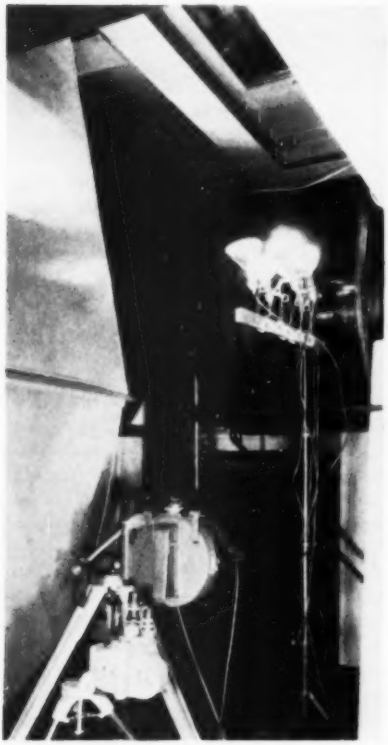

Fig. 8. Camera and lights arranged to photograph tire tread action.

in the methods used in taking pictures of this sort. Rassweiler and Withrow of General Motors Research Laboratories started on the problem of combustion photography well over fifteen years ago and a number of papers on their methods have been presented before various engineering society meetings.[1] This work has been continued right up to the present time under Mr. Withrow's direction. Figure 9 shows one of the quartz-window engines being used for combustion study. One of the principal aims of this work has been to obtain films of the progress of the flame front during both knocking and nonknocking combustion and to observe carbon particle formation. For this work it is not considered desirable to use fuel additives for the purpose of increasing flame brightness, therefore camera frame rates have been held to around 1500/sec or 2000/sec in the interest of good exposure. Sensitive films such as linagraph pan are usually employed and fast camera lenses are required. Lenses of either $f/1.9$ or $f/1.5$ aperture rating are usually used. In Fig. 9 three light sources can be seen. These are ultraviolet lamps which have replaced ordinary incandescent illumination for delineating the cylinder outline. The use of visible light for illumination tended to wash out the exposure of the cylinder area due to the light reflected from the combustion chamber. Now used is an outline mask to which have been applied fluorescent coatings which glow brightly under ultraviolet light. The value of these films depends upon precise determination of crankshaft angle for each frame. This information is provided by the crankshaft position scale seen at the lower center part of Fig. 9. Just above the scale is an optical arrangement which places an aerial image of the scale in the plane of the quartz window. Figure 10 is a view of the quartz window and crankshaft scale as seen from the high-speed camera position. The cylin-

der outline mask has been coated with a variety of fluorescent materials such as vaseline, solium and coatings known as "da-glow," "glo-craft" and others. The various materials on the mask were being compared for intensity of fluorescence. It is interesting to note that in the first use of ultraviolet light on the mask alternating-current sources were employed and the cyclic variations in mask illumination were quite disturbing. Direct-current units are now used to supply the ultraviolet light.

The action of the subject for a high-speed motion picture may have associated with it certain electrical or other phenomena which would add much to the picture if simultaneously recorded. In some cases this information can be conveyed through the use of the timing lamp, but often is too complex for recording by this means. Transducers such as microphones, vibration pickups or strain gages, can be of use in recording this other information on the film. A method we have used to perform simultaneous photography of a subject and associated characteristics is shown in Fig. 11. A cathode-ray oscillograph is used to convert the electrical information to a trace suitable for photography. A small first-surface mirror is positioned so that it combines the oscillograph trace with a view of the subject in the camera field of view. Camera-to-subject distance and camera-to-oscillograph screen distance via the reflected path must be made equal so that a sharp focus may be had on both. Modern cathode-ray oscillographs can provide a trace sufficiently bright for good exposure when using a high-speed camera of the commercial variety at maximum frame speed. The subject of the setup in Fig. 11 was the contact action of an auto radio vibrator and the input current waveshape was displayed on the oscillograph. There are, of course, other methods of showing electrical variations along with mechanical action; however, it is felt that the versatility, sensitivity and ease of calibration as well as trace-positioning simplicity and flat response of modern cathode-ray oscillographs should be fully considered in this application.

The study of valve spring and valve motions in engine work is simplified greatly through the use of high-speed photography. Figure 12 shows equipment used to measure exhaust valve motion on an overhead valve engine. This procedure is similar to one used by Thompson Products Co., and a more specific description of the results achieved is contained in a paper by Thoren, Engemann and Stoddart, presented before the Society of Automotive Engineers.[2]

In the illustration shown, an 8mm high-speed camera was used and mounted horizontally so as to take advantage of the 16mm frame width available when using a special aperture plate. Camera speeds employed were as high as 15,000 frames/sec at higher engine speeds. A vernier indicating device was rigidly mounted to the engine head and the sliding scale which was very light in weight was welded to the valve-spring retainer cap. The resulting pictures of the vernier could be read easily to 0.001 in. of valve movement. The fixed vernier scale was provided with two holes through which the flash tube of a Strobolux flash unit could be seen from the camera position. This flash was triggered from a contact arranged to close at top center for the cam of the valve being studied. Interpolation of the film for camshaft angles between flashes was accomplished by using elapsed frames as a basis. Figure 13 shows valve-motion curves obtained by this method for an engine speed of 4600 rpm. This represents an extreme condition rarely encountered in actual service. The solid line represents the ideal valve-lift curve. The curve traced in long dashes shows the motion with a solid valve lifter and it should be noted that valve open-

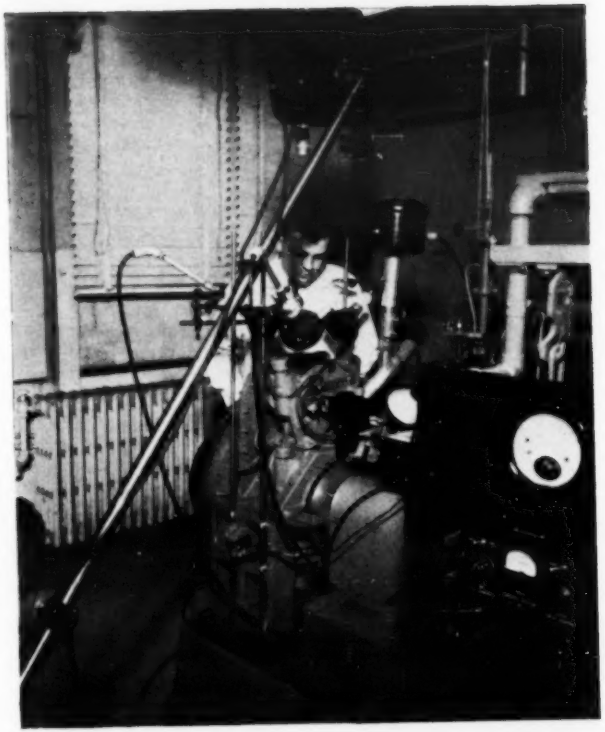

Fig. 9. Equipment arrangement to photograph combustion in quartz window engine.

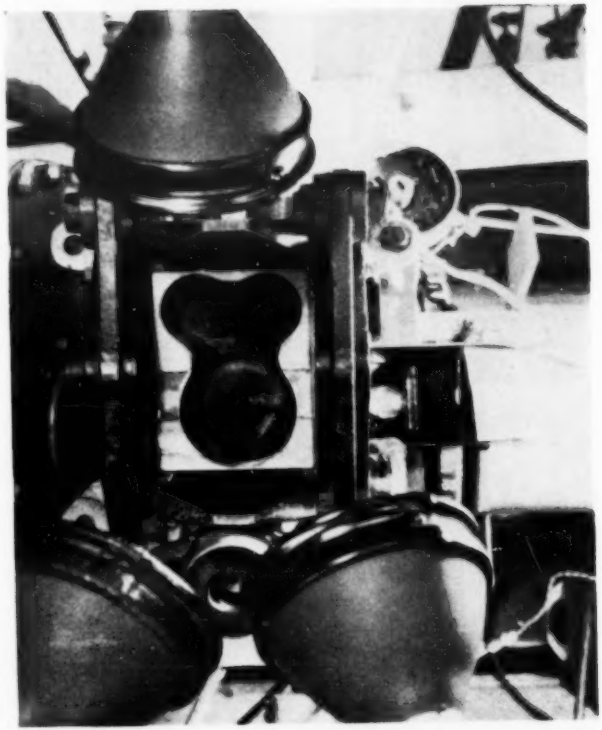

Fig. 10. View of quartz window engine as seen from camera position.

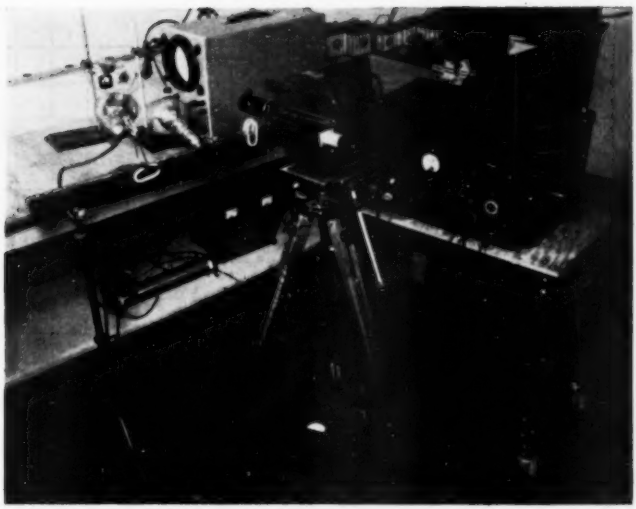

Fig. 11. Setup for simultaneous photography of contact action and oscillograph trace of waveform.

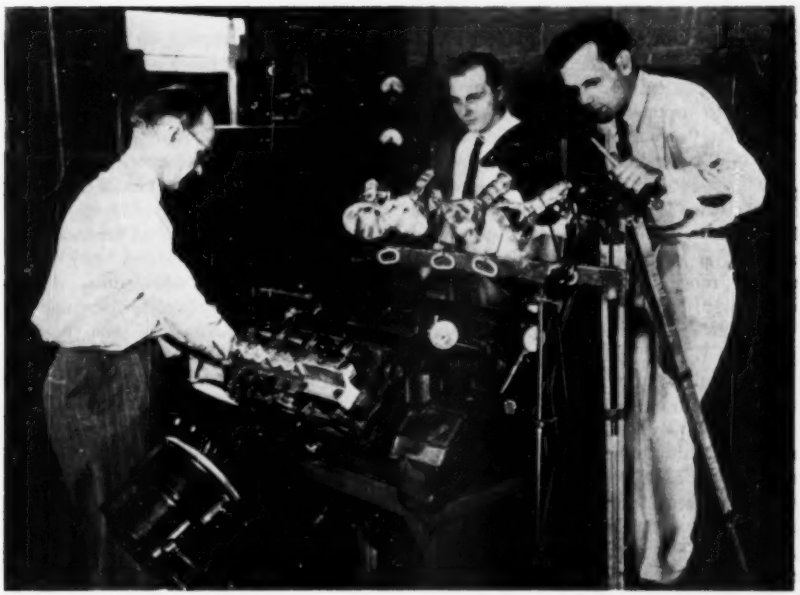

Fig. 12. 8mm camera and equipment used to photograph engine valve motion.

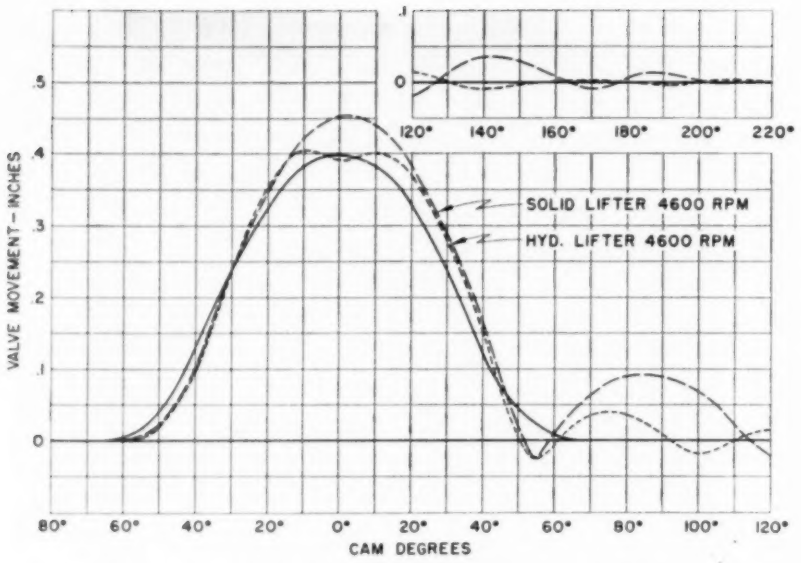

Fig. 13. Valve motion curves for 4600 engine rpm as plotted from film.

ing greatly overshoots the ideal curve at top center and the valve does not follow the calculated curve except as it begins to open. It is interesting to note that the valve goes through about four bounce cycles upon closing before it settles down. The curve traced in short dashes is the one obtained with a hydraulic valve lifter and it is to be noted that even in this extreme condition it more closely follows the ideal curve with less overshoot and evidently with less impact and bounce upon closing. The departure of measured valve motion from the ideal curve is caused by forces and elastic deflections within the valve train at higher engine speeds. This method of checking valve motion is used to verify improvements in valve motion brought about by a method of designing cam contours to allow for the dynamic forces in the valve train at high speeds. Engineers familiar with valve-train design say that no other method is available for checking valve motions as accurately as through the use of high-speed motion pictures.

The methods described here and many others, have been used by General Motors Proving Ground over the past thirteen years with excellent results. They have been instrumental in many product improvements and have pointed the way in a number of instances to more dependable designs and more efficient production operations. High-speed photography seems destined to play an ever-increasing part in our design and experimental activities in the future.

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1. G. M. Rassweiler and L. Withrow, "High speed motion pictures of engine flames," *Ind. Eng. Chem., 28:* 672–677, June 1936.
2. T. R. Thoren, H. H. Engemann and D. A. Stoddart, "Cam design as related to valve train dynamics," *S.A.E. Transactions, 6:* 1–14, Jan. 1952.

A Direct-Projection System For Theater Television

By FRANK N. GILLETTE

The Simplex Model PB-600 contains all facilities required for operation from any of the standard sources of television signal. It projects on the theater screen a full-size television picture of the highest quality compatible with the present state of the art. The system combines simplicity in installation, convenience in maintenance and reliability in operation. This paper describes the circuitry and mechanical features of the system components, and presents the design considerations which governed the development.

THE SIMPLEX system consists of three compact units: a control-panel cabinet, a high-voltage supply and an optical barrel. The installation location of these units is indicated in Fig. 1.

The control-panel cabinet, Fig. 2, contains all of the operating controls and the large majority of alignment and service controls. This unit would normally be installed in the projection booth, but in the case of a crowded booth, many alternate locations are possible.

The high-voltage supply, Fig. 3, can be installed in almost any convenient location. It has no controls, meters or switches mounted on it and should require no attention for months at a time.

The optical barrel, Fig. 4, does have some critical installation requirements. Since the projection optics have a fixed focal length and have, moreover, an extremely wide aperture, the optimum location for the barrel is fixed, within rather narrow limits, by the size and location of the projection screen.

The projection screen itself may be regarded as a component of the theater television system or as a part of the existing theater equipment. The screen should be selected for optimum reflection of incident light into the audience area. This might occasionally dictate the use of a beaded screen, but only if the theater is quite narrow. With a wider theater, beaded screens would probably be rejected because of their very poor performance at large reflection angles.

In many installations it will be advisable to use the screen already present. This screen will presumably have been selected because its reflection properties are suitable for the shape and size of the theater. Of course, the existing screen may be too large, requiring masking to a

Presented on October 15, 1951, at the Society's Convention at Hollywood, Calif., by Frank N. Gillette, General Precision Laboratory, Inc., 63 Bedford Rd., Pleasantville, N.Y.

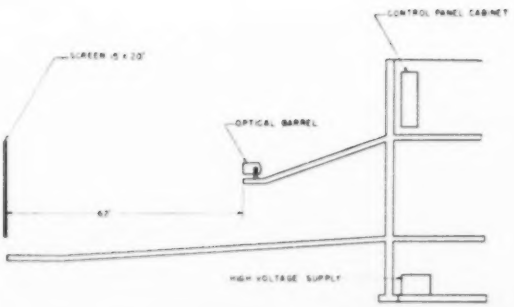

Fig. 1. Equipment locaton, Simplex Model PB-600.

Fig. 2. Control-panel cabinet, Simplex Model PB-600.

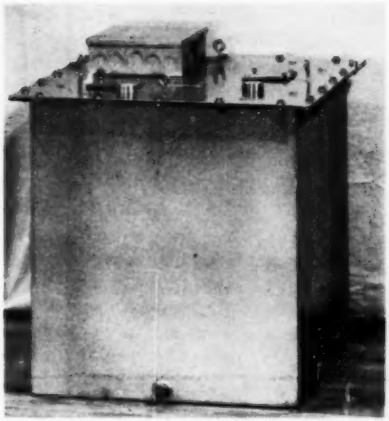

Fig. 3. High-voltage power supply, Simplex Model PB-600.

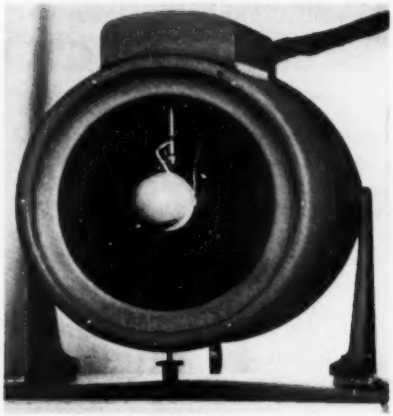

Fig. 4. Optical barrel, Simplex Model PB-600.

smaller size during periods of television presentation.

The optical system is designed to provide a picture 15 ft high and 20 ft wide at a throw distance of 62 ft. The system does permit some variation of picture size and throw distance, but there are also some unyielding restrictions on such variation. The many inquiries we receive on the subject of picture size and throw distance indicate the advisability of calling specific attention to the nature and source of these limitations.

Figure 5 shows the optical elements of the system. The picture is formed on the face of the cathode-ray tube shown at T. Light from the tube face is collected by the mirror at M and directed toward the projection screen at S. The corrector plate is inserted at P for the purpose of correcting aberrations, principally the spherical aberration of the mirror.

The design of the entire optical system is fundamentally controlled by the cathode-ray tube, in this case a Type 7NP4. For good focus over the entire picture area, it is necessary that the curve of the mirror be essentially concentric with the curve of the tube face. It is further necessary that the tube face be located approximately at the focal point of the mirror. Since the focal length of a spherical mirror is equal to one-half its radius of curvature, the foregoing conditions result in a mirror having a radius of curvature twice that of the cathode-ray tube and a system having a focal length equal to the radius of curvature of the tube face.

With the focal length fixed in this way, there is then a single value of magnification for any chosen throw distance. Thus, picture size at a fixed throw distance can be changed only by changing the size of the picture on the cathode-ray tube. If the size is increased too much, the corners will be clipped by the edge of the tube. If the size is decreased appreciably, resolution will suffer. In practice, the dimensions of the picture can be varied some 10% either way from the nominal size.

The magnification is, of course, a linear function of the throw distance, but throw distance is not readily controlled. Throw distance is strongly influenced by the design of the theater and can be manipulated only by reconstruction of a more or less extensive nature. If the preferred installation location provides a

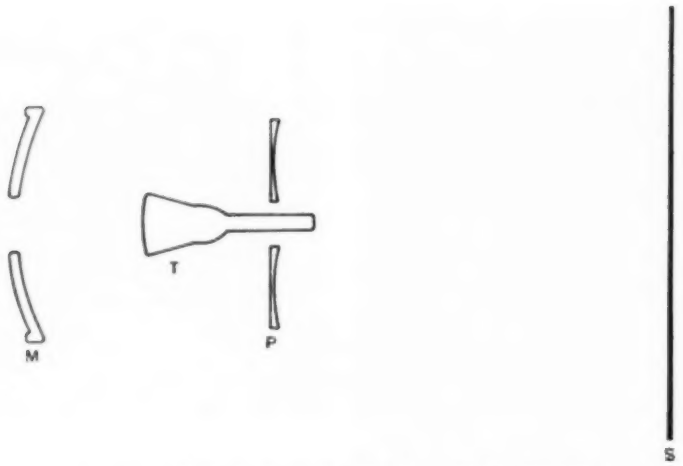

Fig. 5. Optical elements, Simplex Model PB-600.

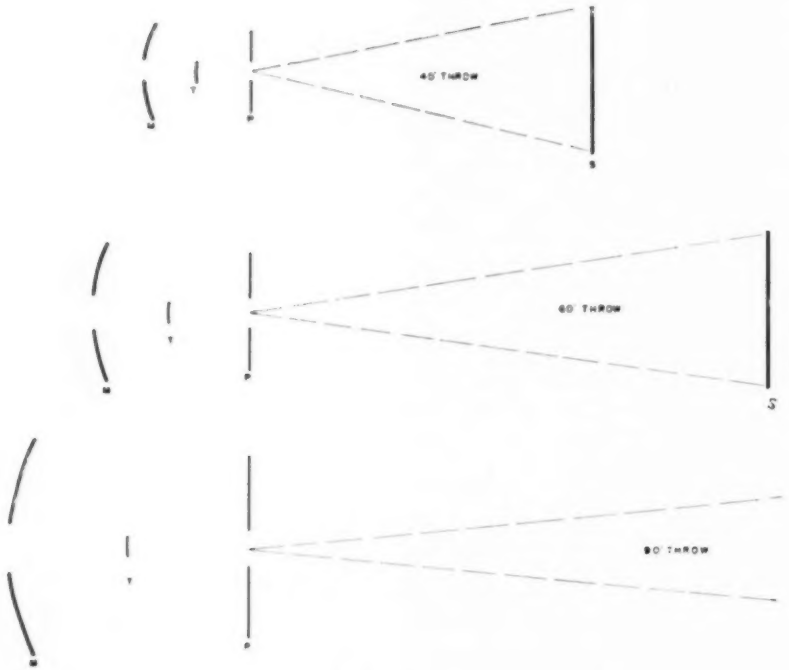

Fig. 6. Effect of focal-length variation, Simplex Model PB-600.

throw that is too short, use of a smaller screen is possible and provides the attendant advantage of increased screen brightness. If the preferred location gives a throw that is too long, the only answer is theater modification. Increasing the screen size is not recommended because the brightness soon becomes unacceptably low.

Theater people are quite familiar with these relationships between picture size, throw distance and focal length. Unfortunately, they are also accustomed to purchasing projection lenses in many different focal lengths scattered over such a wide range as to satisfy almost any requirement of picture size and throw distance. Quite naturally, they expect to find a similar flexibility offered in theater television equipment.

The cost of designing and stocking expensive optical systems of different focal lengths is one obvious reason for not offering such flexibility. Other, and perhaps even more forceful, reasons are indicated in Fig. 6 which shows the effect of focal-length variation. The middle drawing, illustrating the 60-ft throw, shows the components of our present optical system; the upper drawing shows a system using a shorter focal length; the lower drawing shows a system using a longer focal length. As drawn, the three systems provide approximately the same screen brightness.

It will be noted that the diameters of the optical elements of the system of longer focal length are considerably larger than the elements of the "Simplex" system. Not only are such elements much more expensive than those used in the present system, they are also larger than can be manufactured in quantity by existing equipment. The system of shorter focal length involves smaller components which could indeed be manufactured at reasonable cost. However, the angular width of the picture becomes significantly greater. As this angular width becomes larger, the optical design problem becomes tremendously more complex. Adequate correction of optical aberrations in the corners of the picture becomes virtually impossible.

Although an optical system of this type is generally called a Schmidt system, it differs tremendously from the system originally developed by Schmidt for use as an astronomical telescope. Fundamentally, a Schmidt system consists of a spherical mirror, a diaphragm located at the center of curvature of the mirror, and a corrector plate also located at the center of curvature. The diaphragm serves to eliminate third-order aberrations and the corrector plate provides compensation for spherical aberration. The optical quality of this system can indeed be very good, provided the design is restricted to an angular field of something like 1° and an aperture less than $f/3$. For the "Simplex" system, an angular field of 23° and a geometrical aperture of $f/0.7$ is required. Clearly, these requirements are well beyond the limitations of the basic Schmidt design.

The classical Schmidt formulas have been applied to the present conditions with a reasonable degree of success. However, much better results have been obtained by approaching the design problem from a somewhat different point of view. Louis Raitiere of the General Precision Laboratory has succeeded in developing a design approach which results in a system that differs slightly, but very significantly, from the classical Schmidt system. The performance obtained with Raitiere's optical system has been quite gratifying. A limiting resolution in the extreme corner of the field of 2000 television lines per picture height is observed. This figure, of course, applies to the optical system alone and not to the overall system.

The detail-contrast ratio that can be obtained in any system which works with a cathode-ray tube as the basic picture source is never as much as one would desire. The contrast ratio is still further de-

graded by the presence of any dirt on the optical elements of the system. To reduce the rate at which dirt collects on the optical elements, and consequently to minimize the necessity for frequent cleaning, the optical barrel, shown in Fig. 4, has been designed. The barrel is completely enclosed and there is no circulation of outside air through the system. The cooling air which must be directed against the face of the cathode-ray tube, to avoid damage to the tube, is recirculated through the barrel and serves only to conduct heat from the cathode-ray tube to the outer walls of the barrel. The outside of the barrel provides such a large radiating surface that the resulting temperature rise is insignificant.

The use of a closed system also permits quite simple solutions to any problems arising from excessive humidity. Thus far no difficulty with arc-over within the barrel has been encountered, but should such difficulty develop, no trouble in controlling the humidity within the unit is anticipated.

The barrel is supported mechanically at three points. The two pivot points are located at approximately the center of gravity and carry the bulk of the weight of the unit. The third support point is at the bottom of the front of the barrel. Its function is to tilt the barrel and to hold the line of sight, once it is established. The maximum tilt, permissible from optical considerations, is approximately 7°. If it is possible to tilt the screen, a greater tilt of the barrel can be accommodated by the mechanical adjustment provided.

The barrel opens at the top for cleaning and service. The video amplifier and the alignment controls are located here, which makes readjustment or tube replacement very simple. Of course, there are no more tubes in the barrel than is absolutely necessary. Only the final video amplifier is located here.

The cathode-ray tube is mounted in the deflection yoke which is in turn held by a support arm that hangs from the top of the barrel. The support arm fastens to a mounting plate from which it can easily be removed and to which it returns without disturbance of previously made alignment adjustments. All alignment adjustments required by tolerances of the cathode-ray tube itself are made on the support-arm assembly. Thus, any operator who may wish to do so can equip himself with a spare tube support arm in which he can mount and align a spare cathode-ray tube to have it in instant readiness for replacement in case of tube failure. To facilitate this operation, all electrical connections to the cathode-ray tube and the deflection yoke are carried up the tube support arm to connectors that can be quickly disconnected in time of need. With these provisions, a show need not be lost for more than three minutes by failure of the cathode-ray tube.

The 80-kv power supply is shown in Fig. 3. This unit provides the anode voltage for the cathode-ray tube and also the focus voltage.

The circuit employs a 60-cycle voltage doubler using two Type VR3B rectifiers. The output voltage is regulated against variation in both line voltage and load current by an electronic regulator which controls a saturable reactor in series with the primary of the high-voltage transformer. The regulation characteristic is essentially flat from zero current to 2.5 ma. Beyond 2.5 ma, the voltage drops rapidly with increasing current in the manner required for protection of equipment against permanent damage in case of momentary failure.

The focus voltage is bled from the 80-kv level to take advantage of the stability of that level and to provide a focus voltage that will remain proportional to the anode voltage, should any variation in that level occur. Remote control of the focus voltage is provided by a high-voltage triode used as a shunt across the low end of the focus bleeder.

The unit is oil filled for maximum reliability. It also contains a number of electrostatic shields and protective spark

Fig. 7. Control-panel cabinet servicing, Simplex Model PB-600.

gaps on the low-voltage wiring to ensure that any breakdown which might occur inside the unit will have no harmful effect on external circuits.

The booth equipment consists of the Control-Panel Cabinet, shown in Fig. 2. It is a double-relay rack, each rack being of the standard width to accommodate 19-in. panels.

The rack itself possesses a number of special features that deserve mention. The component chassis are strictly conventional, each one consisting of a horizontal chassis with a vertical front panel of standard 19-in. width. However, the method of mounting is such as to provide much greater serviceability than is usually found in equipment constructed in this fashion. Each individual chassis is held in place with two quarter-turn locks. When these are released, the chassis may be drawn forward on rollers until it is fully clear of the rack. This provides quick access to all of the tubes in the rack without the removal of cover plates or other ornamentation (see Fig. 7).

Should the wiring side of the chassis require attention, it is necessary only to lift the front of the chassis and swing it upward through 90° where it will rest in a stable position with the wiring facing outward. In either of these positions the chassis is still connected and still operating.

These provisions make it possible to perform all service functions without access to the rear of the rack. This same thought has been carried further. When all the chassis are removed from the rack, there remains but an empty shell. As a first step in installation, this shell can be bolted, once and for all, in its final position even though this places the back of

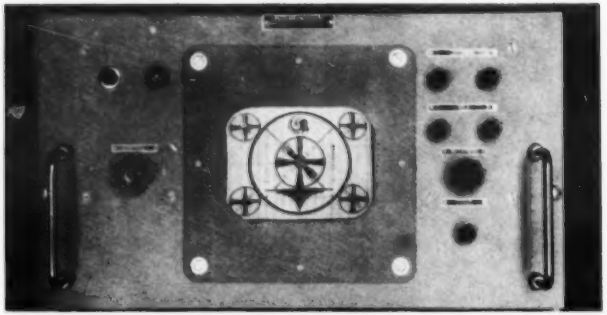

Fig. 8. Picture monitor panel, control cabinet, Simplex Model PB-600.

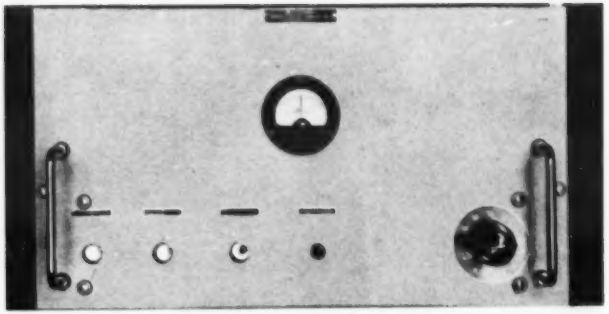

Fig. 9. Receiver panel, control cabinet, Simplex Model PB-600.

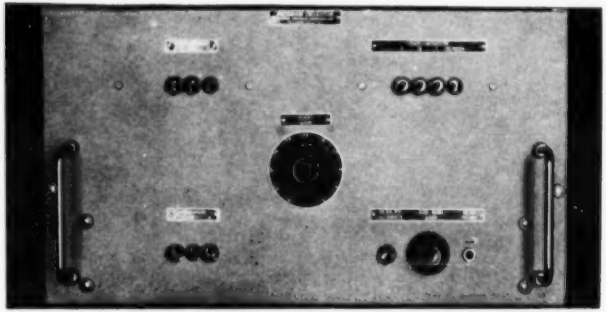

Fig. 10. Program selector panel, control cabinet, Simplex Model PB-600.

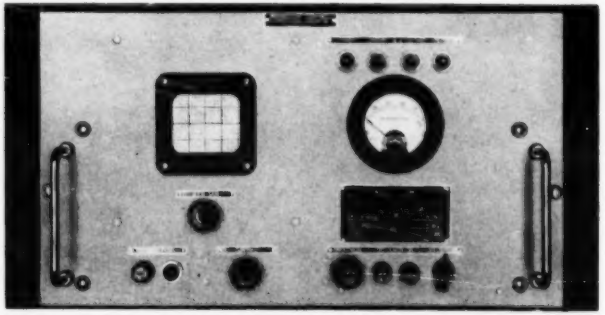

Fig. 11. Projector control panel, control cabinet, Simplex Model PB-600.

the cabinet solidly against a wall. The conduits and cables can then be affixed and the chassis installed without further movement of the cabinet.

The equipment in the racks is so distributed as to place the monitors and meters at eye level and the operational controls at convenient finger-tip level.

The unit in the upper left corner is the Picture Monitor, containing its own power supply. The controls on this unit serve only to adjust the picture on the 8½-in. monitor tube (see Fig. 8).

Below the monitor is a receiver of rather superior characteristics which provides off-the-air reception during periods of test and alignment (see Fig. 9).

The two units below the receiver are the vertical and horizontal deflection chassis (see Fig. 2). These units contain all of the deflection controls, circuits and components except the deflection yoke, which is necessarily located with the projection tube in the optical barrel. The deflection circuits and components are especially designed to permit a long cable connection to the deflection yoke. With the cable usually provided, this run can be 150 ft. With special low-capacity cable, even longer runs are possible. This point is mentioned particularly because this cable run is the only one in the system that bears any restriction as to length.

Below the deflection chassis are two blank panels behind which is located a line-voltage regulator that stabilizes the input voltage to various circuits that are not sufficiently critical to demand electronic regulation, and to the filament transformers of more critical circuits.

The bottom panel of the right-hand rack is also blank. In this space the saturable reactor, which regulates the 80-kv supply, is mounted.

The two chassis directly above contain power supplies which provide the various plate and bias voltages required by all of the circuits except the monitors.

Above the power supplies the Hi-Voltage Control Unit is located. This unit contains all of the low-voltage elements associated with the 80-kv supply except the saturable reactor mentioned earlier. The panel controls consist of pushbuttons for controlling power to the supply and a knob for setting focus-voltage level.

The remaining two panels in this rack are shown in more detail in Figs. 10 and 11. Figure 10 shows the program-selector panel located immediately above the high-voltage control unit. All of the signal switching and audio-control functions of the equipment are performed at this panel.

The system provides for three incoming program channels, each consisting of an audio and a video line. Normally, one of these channels will be connected to the receiver included in the equipment. The second will take the incoming program line. The third might be used for a parallel safety channel for the main program line, for an auxiliary microwave receiver or possibly for a local signal generated by pick-up equipment within the theater.

The switching facilities permit independent monitoring of any incoming audio or video line. The three panel pushbuttons at the upper left connect any of the three audio lines to the monitor headphone jack in the lower right corner of the panel. The gain control for the monitor channel is adjacent to the phone jack. The larger knob sets gain in the program line to the theater. This control is used only to set the audio level from the television equipment to the level required by the input of the theater sound system. It is not considered an operational control.

The pushbuttons at the upper right switch the input signal to the Picture Monitor and also to the Waveform Monitor, yet to be described. The first three buttons select any of the three incoming video lines. The fourth button is labeled "Screen." Its function will be described in connection with the Projector Control Panel. An additional

nonlocking pushbutton, located nearby and labeled "Push to Calibrate," serves to connect a calibrating signal to the Waveform Monitor for use in setting signal levels.

Program switching is done by the pushbuttons at the lower left of the panel. They feed any of the three input channels to the theater system, controlling both picture and sound. Interlocked switching has been used here as another means of eliminating operator error.

Figure 11 shows the Projector Control Panel which is located at the top of the right-hand rack. On the Projector Control Panel are concentrated all but one of the operational switches and controls normally used in turning on and adjusting the theater screen picture. This panel also contains the waveform monitor and a multipurpose meter, both very useful as monitors during projection and as test instruments during preliminary setup.

The equipment will normally be turned on by the four-step procedure outlined below. However, the equipment contains enough interlocks and protective circuits to ensure that no damage will result no matter how carelessly the operator handles his turn-on procedure. In any case the progress of the operation is indicated by the condition of four amber lights at the upper right of the Control Panel. Not until all four are illuminated will a picture appear on the projection screen.

As the first step of the procedure, the main power relay is closed by means of the motor-starting-type pushbutton located below the meter. This causes immediate glowing of the first of the amber lights.

While the circuits warm up and reach normal operating conditions, the second amber light begins to glow, indicating the presence of deflection fields at the cathode-ray tube.

As the second step, power is applied to the Hi-Voltage Supply by means of the pushbuttons located on its control panel. In a short time the anode potential rises to its proper level, causing the third amber light to glow.

At this point, the entire system is turned on and the three lights inform the operator that all interlocks are closed, all supply voltages are present and most of the circuits are functioning in essentially normal fashion. However, there is still no picture on the projection screen because the projection tube is biased well beyond cutoff.

The third step might be considered optional, but is actually essential to good showmanship. It consists of using meter and monitors to preset various controls to ensure that the picture first seen by the audience is a good picture.

The test meter is used first to check the levels of the various supply voltages, including the 80-kv anode supply. It is then used to set the operating bias of the projection tube at the proper level by means of the "Brightness" control. Finally, it is turned to the "2MA" position to serve as a monitor during the projection period.

The monitors, both picture and sound, are used first to check on the quality and the levels of the incoming signals. Then the picture and waveform monitors are switched to their "Screen" position. In this condition, both receive a video signal brought back from the final video stage in the optical barrel, which permits preliminary adjustment, by means of the "Contrast" control, of the actual driving signal applied to the cathode of the cathode-ray tube.

Furthermore, when the Picture Monitor is switched to the "Screen" position, its horizontal and vertical sweeps are synchronized directly by pulses obtained from pickup coils wound into the deflection yoke of the projection cathode-ray tube. Since these pulses are actually a measure of the magnetic deflection fields applied to the projection tube, a normal picture on the Picture Monitor is a positive indication that the deflection

signals, applied to the projection tube, have the correct frequencies and essentially the correct amplitudes.

All is now ready for the fourth step. Turning the "Picture" switch to "On," illuminates the fourth amber light, switches the projection tube from cutoff to operating bias and presents the picture in essentially perfect adjustment.

The cathode-ray tube used in this system is rather expensive and, while it is an amazingly tough device when treated properly, it is highly fragile when mistreated. These remarks apply equally well to personnel who operate and maintain the equipment. Consequently, the equipment includes an elaborate system of interlocks and safety devices for protection of tubes and personnel.

The interlock system prevents the application of primary power to the high-voltage supply unless all doors giving access to the anode and focus voltages are closed and all chassis in the rack are in place. The protection system allows beam energy to reach the tube face only when the following conditions are satisfied:

1. Proper voltage levels exist in the +750-, +400-, +285-, −105- and −150-v power supplies.
2. The 80-kv supply is up to operating level but not in excess of 82 kv.
3. Horizontal and vertical deflection fields have at least 75% of their normal amplitudes.
4. A substantial stream of air is blowing against the tube face.

The projection system is designed primarily to prevent damage to the 7NP4 projection tube, but it also serves to protect the remainder of the system against bias failure.

Throughout the system, the protection circuits have been designed to work directly from the critical quantity and not from signals which usually, but not always, denote that quantity. For example, the circuit which protects against sweep failure might work with almost complete safety from various currents or voltages that are readily available in the deflection circuits. Actually, in this case, the critical quantity is the magnetic field in the gap of the deflection yoke. Our protection system includes pickup coils in the yoke which measure the magnetic fields and thus give positive and complete protection against sweep failure.

In designing the system described above, the goal of providing quality of performance, exceeding the requirements of present television standards, has been pursued. The degree of success that has been achieved justifies a prediction that the Simplex equipment will not be found wanting whenever higher performance standards may be adopted.

Discussion

Anon: You mentioned that there was no restriction on the physical separation of the various components in this system with the exception of one point that I don't recall now. How about the distance between the 80-kv power supply and the optical barrel? Won't you get into trouble there with high capacity if you have that distance too great?

F. N. Gillette: In that case you're not in any trouble because of high capacity. Indeed, the cable capacity can be used as an essential and valuable part of the filter system on the 80-kv. If we were actually obliged to use a very short cable we would find it necessary to add capacity in the power supply. We've left space for this purpose in case we hit such an emergency, but we're definitely planning on the capacity of the cable as part of the filter system.

Anon: That isn't the point I had in mind. The larger the capacity in the output circuit of the high voltage power supply the more lethal the thing becomes.

Dr. Gillette: The thing is lethal without any doubt. I don't think it's possible to reduce the capacity to a value which would not be lethal. The only remedy seems

to be to prevent access to the voltage. From the point at which it emerges from the supply itself, until it disappears into the barrel, the high voltage lead is encased in the outer conductor of a coaxial cable and the cable is run in a conduit. We think that's better than trying to keep capacity down.

L. D. Grignon: At the Lake Placid 68th Convention you described a proposed system of 675 scanning lines with a 24/sec frame rate. Is this such a system?

Dr. Gillette: At the moment this is not such a system. We have operated the system in that fashion just to find out how much further we have to go and we are satisfied that we need considerably more filtering in the system than we now have. The observed modulation of any image point is perhaps two television lines. Most of the modulation comes from ripple on the high voltage supply. A small amount is very definitely in the deflection system. These ripple effects are easy to remove, but the equipment we are now constructing is not 675–24 equipment.

Progress Committee Report

PROGRESS in the motion picture studios during 1951 was mainly another step forward in the application of new color systems and in the completion of the installation and operation of magnetic recording equipment.

Feature pictures made with Eastman negative-positive color, Ansco negative-positive color, Eastman color negative with Du Pont color positive, and Eastman color negative with SUPERcine-COLOR color positive are in release.

While the continued economy drive has tended to restrict the production value of some pictures, many producers are experimenting in order to determine just how much the illusion in a picture may be enhanced by the increased scope which is provided by large, spectacularly illuminated sets and complicated routines. As a case in point, the concluding ballet scene in *An American In Paris* was filmed after the picture in its original form was completed![1]

The Telecinema at the Festival of Britain in London deserves special mention in the introduction to this report.[2] This theater was built to demonstrate technical advancements in the projection of motion pictures, sound, and large-screen television. It is open to the public on an admission-fee basis and at last reports was self-supporting.

Large-screen television is shown and people arriving in the auditorium proper see on the screen others in the foyer who are about to enter. Stereoscopic color motion picture short subjects of the Polaroid variety are shown along with stereophonic sound. The theater has a maskless screen with an illuminated surround which changes brightness with the intensity changes in the picture.

The Motion Picture Research Council in Hollywood has described its work on the investigation of stereoscopic motion pictures stating that thus far the major producers have not used the presently available systems on anything but a novelty basis. These systems have been described in various articles and papers.[3-8]

An announcement was made that Arch Oboler will start soon on a "three-dimensional" film in Hollywood which will utilize the Natural Vision Process for both taking and showing.[9] In this process the pictures are photographed with two synchronized cameras. They are projected with two synchronized projectors having polarizing filters over the lenses and are viewed with Polaroid spectacles. The system will require four projectors for a full-length feature, or for production to be made in such a way that special intermissions may be used for rethreading. It was stated that either film may be used for two-dimensional showing. Demonstration films have been exhibited to invited groups by M. L. Gunsburg who is the head of the Natural Vision Process.

An interesting development during 1951 has been the formation in Great Britain of a new company known as High Definition Films Limited, whose object is to develop electronic camera and kinescope recording equipment suitable for use in film studios for pro-

Submitted, April 22, 1952, at the Society's Convention at Chicago, by Charles W. Handley, Committee Chairman.

duction of first-feature films. The intention is to use a television camera to record the scene on a pickup tube, this picture then to be photographed on motion picture film in the conventional manner. It is planned to develop equipment having a sequentially scanned 900-line picture in order to obtain the necessary quality. The company is staffed largely by engineers recruited from The British Broadcasting Corporation television service and is headed by Norman Collins who was until recently Controller of B.B.C. Television. Initial development work on the necessary equipment is planned to take two years. The company hopes to rent equipment to studios requiring it for production purposes. The proposals outlined by High Definition Films Limited have met with a mixed reception from the film industry and it remains to be seen to what extent they will be accepted.

The Naval Photographic Center successfully completed the experimental utilization of television equipment to produce a motion picture training film. Employing television cameras and television studio techniques, the motion picture negative was exposed by kinescope recording. Sound was simultaneously recorded on a standard film recorder. Composite prints from these negatives were distributed in the usual manner and are adequately fulfilling the requirements of a Navy training film. From the Navy's point of view, the production work load does not appear to warrant employment of such equipment at this time. In time of full mobilization, when production time must be greatly shortened, it is probable that serious consideration will be given to the production of Navy training films with television equipment.

Motion pictures on tape have been listed as a possibility for practical future use.[10] Several people are reported to be working on magnetically recorded motion pictures in which no optics are used in the electronic "camera." It is claimed that a demonstration was made whereby the picture was recorded on a $\frac{1}{4}$-in. magnetic tape from a home television reception of a motion picture film being televised. Images in the rebroadcast were fuzzy but comparable to results obtained with early TV receivers.

Additional television equipment has been installed in theaters throughout the country. These installations include both the direct projection system and the intermediate system. Considerable publicity has been released on the Swiss Eidophor system which was mentioned in the Progress Report of 1950. Preliminary demonstrations for the press and motion picture industry people were conducted in Zurich during mid-November 1951. Preparations are now being completed for early demonstrations in New York.

Color Processes. At least three studios are equipped to do all or a part of color processing on a limited number of full-length color features.[11]

Consolidated Film Industries report additions and new equipment for color processing which enable them to handle the various negative-positive color processes and also to make 35mm theater release prints from 16mm Kodachrome originals, as well as 16mm color reductions on Kodachrome from 35mm Eastman color negative.

Pathe Laboratories, Inc., have also installed equipment for the handling of color processes and additional auxiliary equipment is being built.

Cinecolor Corporation has stated that its processing capacity for color coupling films has doubled during 1951. Also that SUPERcineCOLOR processing has been set up in the Cinecolor (G.B.) laboratory in England.

It was reported that an increasing demand for color film was noticeable during 1951 in Great Britain, but shortage of suitable raw stock reduced the actual footage used. Technicolor

Table I. Releases on Various Color Processes.

Picture	Studio	Negative Type	Positive Type
Greatest Show on Earth	Paramount	Technicolor 3350 K Balance	Technicolor
Golden Girl	20th Century-Fox	Technicolor 3350 K Balance	Technicolor
The Belle of New York	M.G.M.	Technicolor 3350 K Balance	Technicolor
The Lion and the Horse	Warner Bros.	Eastman	Eastman
The Wild North	M.G.M.	Ansco	Ansco
Honey Chile	Republic	Eastman	Du Pont
Jack and the Beanstalk	Warner (Release)	Eastman	SUPERcineCOLOR

and Gevacolor were the only 35mm processes available.

Changes in color sensitivity of the Technicolor process from a white-light balance to a color-temperature balance of 3350 K has been accomplished and the majority of Technicolor pictures now in production are being made with that system. The camera filter arrangement is changed when shooting with white light on interiors or when shooting exteriors.

Table I shows some of the pictures now in release which were made on the various negative-positive color processes.

The J. Arthur Rank Organization in Great Britain have adopted Ektacolor sheet film for preparing stills for back projection. The scene is photographed on a 5-in. × 4-in. Ektacolor negative and then reduction-printed on Ektacolor positive to a size 3 in. × 2.2 in., which is required for the back projection slide.

35mm Photography

A new synthetic base for photographic film has been developed by the Du Pont Company.[12,13] Greater toughness and dimensional stability are claimed for this than for other types of safety base film. Two years will be needed to complete large-scale manufacturing facilities.

In England the J. Arthur Rank Organization are reported to have used an improved traveling-matte system on a large number of pictures. This process, designed for monochromatic photography, involves the use of a special beam-splitter camera and special colored lighting. The process can be used on almost any subject and does not suffer from the limitations imposed by subjects such as smoke, fine detail, reflections in glass, etc.

Lighting Equipment and Techniques. The change in color sensitivity of the Technicolor process from a white-light to a color-temperature balance of 3350 K has brought about a large increase in the use of incandescent lamps on that system. On small sets and in places where the light from the incandescent lamp is adequate, the illumination may be largely, or entirely, from the incandescent tungsten sources. It is possible to use this system on either a 3350 K balance or a white-light balance by changing the filter arrangement at the camera. During the introduction of the system the incandescent lamps were left unfiltered and the carbon arcs used for effect lighting were filtered to the lower balance. Recently some directors of photography have been reverting to a white-light basis and filtering the incandescents for certain large-area sets like a theater shot in which follow-spots are used, or a night exterior.[14]

The foregoing changes have brought the 10-kw incandescent lamp back into

Fig. 1. Paramount 5-kw incandescent remote-control lamp.

use as well as a unit which is known as Type T-5.[15]

The Paramount Studio's engineering department has developed a remote-control lighting system for use with incandescent lamps (Fig. 1). With this system, lightweight units mounted in various places may be moved at almost any angle, or the focus changed by motor control from a remote master station.[16] The system was designed for use on a circus picture where the lamps had to be mounted on the tent poles; however, it is being adjusted with the thought of bringing studio lighting to an automatically controlled operation insofar as possible. At the time of this writing only the one studio had built any of these motor-drive-controlled units.

Cameras and Accessories. Details of a new combination aerial combat-reconnaissance camera have been announced by the Bell & Howell Co.[17] It is a lightweight, portable, 35mm motion picture camera designed to Air Force specifications by the company in co-operation with Air Force engineers.

35mm Sound Recording

The report on progress in sound recording deals almost entirely with developments in magnetic recording.

Those motion picture producers who had started the conversion of their plants from photographic to magnetic recording during 1950 completed the change-over during 1951, with the result that by the end of last year approximately 75% of the original production recording, music scoring and dubbing in Hollywood was being done on magnetic recording equipment.

Magnetic recording has also found wide use in western continental Europe. For motion picture recording both 35mm and 17½mm films are used. In England the adoption of magnetic recording facilities by studios during 1951 proceeded with considerable caution. It was reported that British Lion Studios at Shepperton are installing five magnetic conversion kits for their Western Electric photographic recorders and Associated British Picture Corporation at Elstree are planning to install five channels of RCA 17½mm magnetic sound equipment.

As a result of experience with magnetic recording during the year, economies anticipated in 1950 were realized in 1951. Through the use of equipments designed to record three tracks on the one strip of film, very worth-while reductions in storage-vault requirements were made and the cost of dubbing domestic and foreign versions was materially reduced.[18,19]

At the Columbia Studios, storage-vault requirements were reduced by a ratio of better than ten to one and the cost of dubbing foreign versions at this same studio was reduced two to one.

By the use of magnetic equipment on

original production recording, great savings have been effected in the quantity of photographic film used by the industry. This stems largely from the dractices of transferring only choice takes from magnetic to photographic film for dailies and for editing purposes.

A number of problems have arisen during the year connected with the use of magnetic film, one of the most serious of which has been the problem of editing.[20] A number of solutions have been offered, some of which have been adopted with varying degrees of success. Among the solutions, the following may be listed as having the most promise:

1. Magnetic recordings may be transferred to negative photographic film from which prints are made.

2. They may be transferred to direct-positive photographic film which can be used for editing and re-recording.

3. The transfer may be made to a film carrying both photographic and magnetic media.

4. The magnetic material itself may be edited.

The problem of editing the magnetic material itself remains one of the most difficult, and while several designs of editing and splicing equipment have been made, it appears that a satisfactory magnetic film splicer and splicing techniques still remain to be produced.

Paramount Studios report that their magnetic recording program has now been extended to the first phases of magnetic sound editing, and that striped magnetic prints are now replacing direct-positives for this purpose.

Columbia Studios have introduced during the year a combination magnetic and photographic print for editing.

Warner Bros. Studios transfer all magnetic recordings to direct-positive for dailies, for editing purposes and for previews.

Another problem which has received considerable attention during the year has been that of magnetic head wear. Much thought and attention has been given to this problem and solutions appear in the design of magnetic recording heads of harder materials or in the plating of existing heads with some wear-resisting material such as chromium. The latter solution has been adopted by Columbia Studios. It is probable that this particular solution, however, will be superseded as newly designed heads appear and the expensive procedure of removing heads, replacing them in correct alignment and putting them through the plating process will be discarded.

In the use of triple-track recording equipment, problems of crosstalk between tracks and of complete erasure of all three tracks appeared and were solved during the year.

New magnetic recording equipments emerged from the design to the production stage during the year 1951. Among these may be listed a portable magnetic recorder manufactured by RCA for Warner Bros. Pictures, Inc. (Fig. 2), which records a magnetic track on 17½mm film and operates at a speed of 45 fpm.[21] The use of this film width and film speed constitutes a fourfold saving of film cost compared to the single-track magnetic recordings made on 35mm film operating at 90 fpm. Also manufactured by RCA during 1951 and put into service at Warner Bros. was a direct-positive recording optical system using a variable-area Class A push-pull type of sound track. In addition to providing a positive-type sound track, this system also provides anticipatory noise reduction.

Two new magnetic recording and reproducing systems were introduced to the motion picture and television industry in 1951 by Westrex Corp. The 1100 Portable Magnetic System, which is contained in two units, provided for high-quality recording or reproduction with 35mm, 17½mm or 16mm film in synchronism with picture. New features of this system include two-way talk-back between the mixer and recordist, a

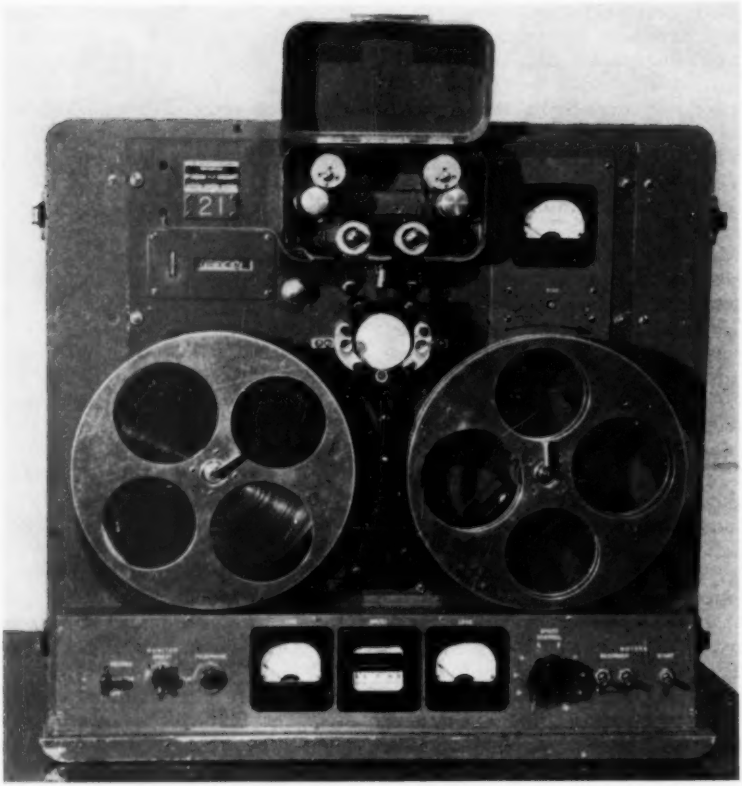

Fig. 2. RCA portable 17½mm 45-fpm magnetic recorder. (Courtesy of Warner Bros. Pictures, Inc.)

new synchronizing bloop unit which records an audible signal on the magnetic film in synchronism with an optical bloop when the recorder is up to speed and it is designed for operation with synchronous, interlock or multiduty motor systems.

The Westrex RA-1506-A Recorder shown in Fig. 3 is a cabinet-mounted equipment containing three independent recording and reproducing channels. Crosstalk from adjacent tracks is kept to a level of −60 db by the introduction of magnetic decouplers in the multiple-head structure.

Tape recording of sound made several gains in 1951. There was substantial improvement in the magnetic tapes available with respect to both mechanical and electromagnetic qualities. There were general improvements in the machines available both in the home and professional fields. Tapes operating as low as 1 in./sec that reproduce voice quality have been demonstrated. There is a trend toward lower tape speeds with 7½ in./sec becoming more important to broadcasters. Fifteen inches per second is becoming common for

high fidelity, with 30 in./sec in use only in a few places for such work as master recordings. Tape duplicating service has been announced where several copies can be made from one original at several times normal recording speed.

In the manufacture of magnetic recording materials, considerable emphasis has been placed on uniformity of coating and the proven results of roll-to-roll uniformity have aided in the acceptance of magnetic recording as the number one recording medium. A significant contribution was made during the past year by the Reeves Soundcraft Corp. through its commercial introduction of 16mm and 35mm film having magnetic stripes for magnetic recording. After two or three years of development work, its availability on a commercial basis was finally announced in February 1951. Magnetic striping can also be added to a customers photographic film which has already been processed.

Some progress was made during the year toward standardization of magnetic track position and track width in 16mm, 17½mm, 35mm and striped 16mm and 35mm films. However, as of the present date, no final standards have been adopted and much work remains to finally settle this debatable issue.

Temporary frequency azimuth test films have been made available. Final versions of these test films, theater test films, and azimuth test films, covering the full width of the film to accommodate any track position, are at present in work.

The Armed Services are making ever-increasing use of magnetic recording and it is reported that they have used over one million feet of striped film on which the magnetic striping covers one-half of the photographic sound track. These films are used where it is necessary to record information in a foreign language and still have the English version available for reproduction.

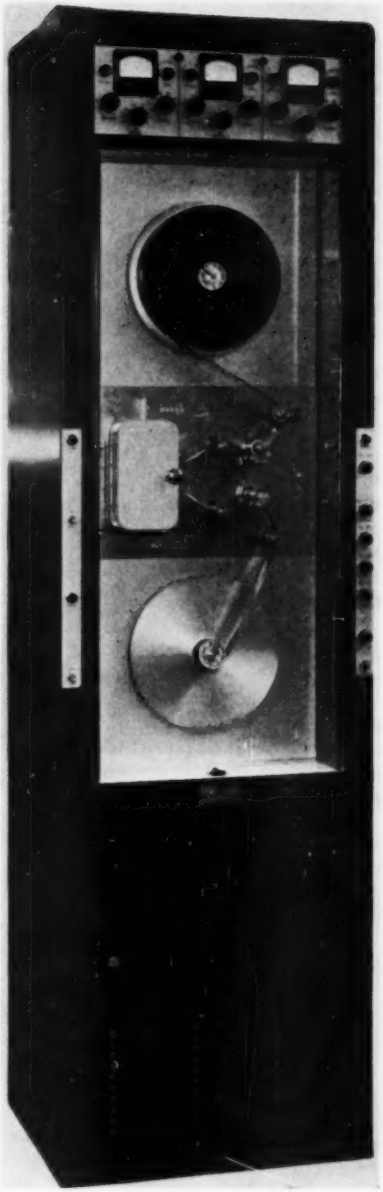

Fig. 3. Westrex RA-1506-A triple-track magnetic recorder.

To divert from the field of magnetic recording, the Eastman Kodak Co. introduced during the past year the Eastman high-speed positive safety film Type 5305. This is a film having the high speed of Eastman sound recording film Type 1357 and the finer grain of Eastman release positive film Type 1301, both of which the new film supersedes.

The results of a study of the technique of making sound-track prints on Eastman color print film Type 5381 were reported.[22,23]

16mm Photography and Sound Recording

In the field of 16mm recording, new equipments have been introduced by both RCA and Westrex. A number of 16mm magnetic recorder-reproducer equipments (PM-66), operating at 36 fpm and capable of being electrically interlocked with 35mm cameras or projectors, were manufactured by RCA.

A 16mm photomagnetic re-recorder, manufactured by Westrex Corp. (Type RA-1509-A), is a cabinet-mounted equipment which provides facilities for recording and reproducing magnetic sound track and for reproducing photographic sound track at synchronous film speed.

Berndt-Bach Corp. of Hollywood has built a new 16mm professional-type camera which provides for a maximum of 1200 ft of film and is known as the "Super-1200." It is a sound-on-film type and is reported to run so quietly that no external blimp is required (Fig. 4).[24]

Both Consolidated Film Industries and Pathe Laboratories, Inc., in Hollywood have provided for new building facilities for the developing and printing of 16mm film. These new facilities reflect the widespread demand for 16mm prints in the educational, religious and commercial fields, together with the increasing demands of the television industry.

The Air Force has developed a system of three-dimensional motion picture photography and projection employing a Polaroid method for right and left picture selection. 16mm high-speed, normal-speed and time-lapse stereoscopic color motion pictures have been demonstrated which used a single projector equipped with a synchronizing drum polarizer in front of the lens and a Morgana-type shuttle mechanism.[4]

Third-dimension converters for 16mm cameras have been described. The camera and projector converters, screen, and Polaroid glasses are being sold as a package unit by the Nord Company of Minneapolis (Fig. 5).[25]

A prototype of an automatic-loading motion picture camera has been designed and produced for the Naval Photographic Center by G. J. Badgely. The insertion of the magazine causes the feed and take-up sprockets of the camera to rotate, automatically picking up predetermined lengths of film, and forming the film into loops before and after the picture aperture. In its development for television recording, the camera uses a single motor to drive the mechanism. Stabilization of the shutter is accomplished by a combination of slipping rim and hysteresis drag. Provisions are made to observe and correct shutter banding while the camera is in operation.

The Naval Ordnance Laboratory has employed the image phototube as a high-speed camera shutter. Having a greater efficiency than the Kerr cell, a light gain is possible. The angle of view is governed entirely by the lens system used.

The Springfield Arsenal has designed a slide rule for analyzing high-speed motion picture data. It performs several basic calculations which must be repeated often in the evaluation of high-speed photography in mechanics research. It permits more rapid calculations with fewer errors and with less highly trained personnel.

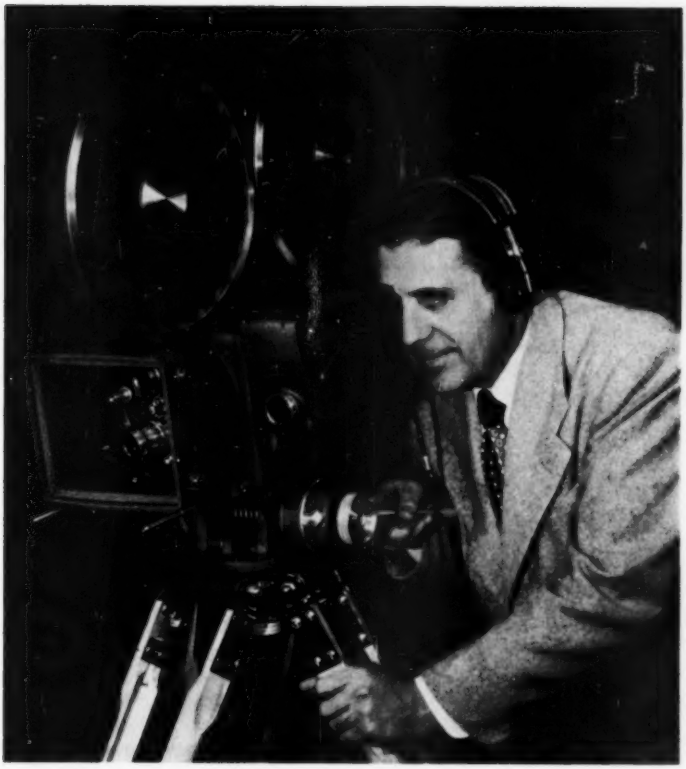

Fig. 4. New Auricon "Super-1200" 16mm professional camera.

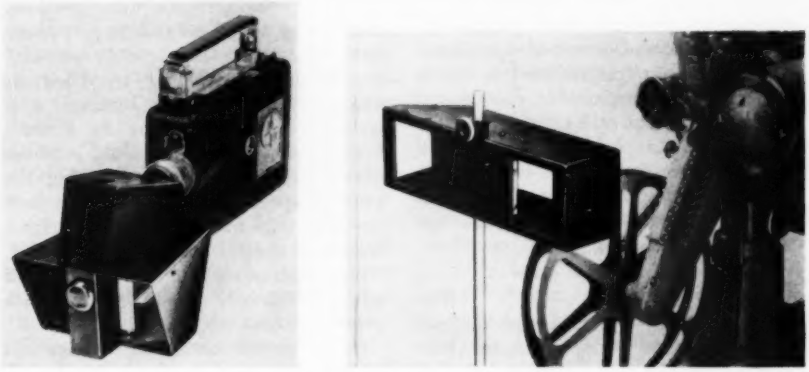

Fig. 5. Nord third-dimension converter for any 16mm camera and projector.

35mm Picture and Sound Reproduction

Means of removing heat from film in projection is still receiving considerable attention. Interference-type heat filters and mirrors have been written about and tested, heat-absorbing glass filters, compressed air from jets and water-cooled aperture plates are in use on different types of projectors.[26–30]

There has been a renewed interest in maskless screens and illuminated borders. Several theaters have installed maskless screens. At the Telecinema at the Festival of Britain the surround changes intensity with changes in screen light.[2,31–33]

A considerable portion of the September 1951 issue of the *Journal* was used for papers relating to screen brightness and viewing conditions. A further report on screen brightness discussed screen light distribution.[34]

16mm Picture and Sound Reproduction

Important in the field of 16mm sound reproduction is the introduction by a number of manufacturers of models designed to play magnetic and photographic recordings.

The new RCA "400" dual-purpose projector makes possible the recording of magnetic sound on processed 16mm films without studio facilities. It also projects sound films having optical tracks. It opens up wide possibilities for nonprofessional sound-film makers.[35]

Bell & Howell introduced a 16mm magnetic recorder-projector, Filmosound Model 202, which will record sound on 16mm films, also play back either optical or magnetic sound tracks interchangeably. The company has also introduced its own sound striping service (Fig. 6).[36]

Television

Even though seriously handicapped by the Federal Communication Commission's freeze on the construction of new television stations, television as an industry has enjoyed fantastic growth during 1951. One of the largest networks is reported to be a very close second to *Life Magazine* in paid advertising income. Even more startling is the advance made in the manufacture of television receivers and accessories. The industry is now one of the leading manufacturing activities in the country and 1951 sales were in excess of $1\frac{1}{2}$ billion dollars.

In the annual report recorded in this *Journal* last year, comment was made on the increase in quality of programming produced by the television networks.[37] This trend has continued and now it is common for a single television show to be budgeted as high as $75,000. Such large budgets are justified on the basis of increased live coverage now available to the networks. The microwave relay and coaxial cable system has been considerably extended during the year. On September 4, 1951, the first transcontinental television program was broadcast on the occasion of the Japanese Peace Conference.

There has been a marked increase in the use of theater television during 1951. Sporting events and other special events have been delivered to theater audiences on an exclusive basis. The increased use of theater television has been responsible for reduction of the cost of equipping theaters for this purpose, thus giving added impetus to this phase of the industry. The final growth and development of theater television is, like many phases of the business, controlled to some degree by the Federal Communication Commission. Much discussion has taken place during the year on specific allocations to be used for relaying television pictures from theater to theater and from city to city. These discussions are still active and will undoubtedly continue through a portion of next year.

Although the backbone of television so far has been based on black-and-white pictures, color television has re-

Fig. 6. Bell & Howell Filmosound Model 202, 16mm magnetic recorder-projector.

ceived considerable attention during 1951. The prolonged FCC hearing on this subject was concluded on October 25, 1951. In spite of this activity in the color field, the commercialization of color is still in the future and is beset with numerous complications, not only regulatory and economic, but also in terms of equipment design and manufacture.

Film, both direct and in the form of video recordings, has continued to be a major source of programming for many television stations. The networks have produced thousands of feet of recordings and, in addition, many independent film companies have been active in the production of special features for the industry. Great progress has been made in controlling the cost of these special features and at the same time retaining acceptable quality for television broadcasting.

Video recording is still largely done on 16mm stock. There is some trend, particularly in larger stations, toward the use of 35mm for such recording because even though the television system is limited, on account of the standards which have been adopted, 35mm equipment can produce demonstratively better recording quality.

With the opening of the transcontinental microwave relay for television, the Hollywood television studios were confronted with a three-hour time differential between the East Coast and West Coast. Programs originating in the East at 8 P.M., for example, would be available at the West Coast at 5 P.M., a time when most people would not be able to view the program. Accordingly

35mm kinescope recording and processing facilities were set up to handle a half-hour show of 3000 ft of film per reel.

Television in France is about where it was in America five years ago. There are regular daily transmissions from Paris and Lille by the Radiodiffusion and Television Francaises which is government owned and is directed by the Ministry of Information. The programs are largely five-year-old films, live studio sketches and stage plays, a daily newsreel, and a weekly newsreel from twenty years ago. This is partly financed by an annual license fee due on each receiver equal to about ten dollars. It is estimated that there are about 50,000 receivers in operation.

In Belgium, Holland, Germany, Switzerland and Spain there are experimental transmissions by private interests. In Italy there are regular broadcasts from the Vatican.

There is some divergence between the signal characteristics used. France uses a provisional low-standard 441 lines, as well as high-definition 819 lines. The 441 lines is scheduled to be abandoned in 1961. The other countries are tending toward the Dutch and German standard of 625 lines. Fifty cycles per second interlaced vertical scanning is used by all. Video modulation here is positive, so that white corresponds to rf modulation peaks, and sync pulses to rf minimums. The radio-frequencies in use at present are 40–50 mc for London and low-definition France, and 175–190 mc for the high-definition. London of course uses 405 lines.

There is one microwave radio relay link between Paris and Lille, and several others under study in France and Italy.

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Magnetic Print-Through— Its Measurement and Reduction

By LYMAN J. WIGGIN

A simple dynamic method of measuring the value of print-through and then a method of reducing it below audibility by application of a supersonic erase bias during playback are described.

MAGNETIC RECORDING is today's nearest approach to perfection in sound recording and reproduction, especially with the use of quarter-inch tape. However, there is one flaw in this "near-perfect" method which, in some instances, makes it unacceptable. This problem is magnetic print-through, which causes echoes to be heard preceding or following a signal. This is caused by the magnetic field, which surrounds the recorded signal, magnetizing the coating on adjacent turns of the roll of tape. In a typical tape application using 2500-ft rolls at a 15-in./sec speed, adjacent turns are played at intervals of from 1 to 2 sec. In certain types of recorded sounds, particularly voice with no background, there are frequent pauses of sufficient duration where the print-through can be audible enough to be annoying. Unfortunately the loudest print-through comes just before the signal, giving a pre-echo which is never found in natural sound and so is not accepted by the ear to the same extent as a post-echo. It is also very damaging to certain dramatic effects and to music, particularly loud chords following rests where the effect is lost by the warning given by the pre-echo. These spurious signals have been termed print-through.

Reeves Sound Studios encountered this problem shortly after installing an elaborate system of making all original recording on Fairchild "Pic-Sync" quarter-inch tape recorders. Intensive research was initiated to see what could be done to solve the problem.

The first tests tried involved listening to recorded 1000-cycle pulses under various test conditions, changing the monitor system gain for each test to get either the same audible level of print-through or just not any, and then comparing the monitor system gains. This method proved to be unsatisfactory and inconclusive.

It was realized that some positive means of measuring the quantity of print-through had to be found. The quantity of print-through that could be tolerated had to be determined also.

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Edward Schmidt for Lyman J. Wiggin, Reeves Sound Studios, Inc., 10 East 52 St., New York 22, N.Y.

Permissible Amount of Print-Through

In order to find out how much print-through could be tolerated, a tape with male and female voices recorded on it was reproduced in a studio. The monitor system gain was adjusted so the acoustic level was as loud as the loudest level ordinarily used for that studio. Then the channel system gain was reduced by known amounts of attenuation until the reproduced signal was just inaudible. This was found to be about at the point where 55 db of attenuation was used.

This same experiment was carried out in a different studio with different personnel conducting the experiment. The result was the same.

Thus, the maximum print-through value which could be tolerated was 55 db below 100% program level. This figure was later corroborated very closely by production department observations.

Method of Recording a Print-Through Test

The following dynamic method of measuring the quantity of print-through was developed as a fast and direct method. A roll to be tested is completely erased before this test is made. A 2500-foot roll of tape is used. This has an outer diameter of about 10 in., and at 15-in./sec tape speed the supply spool turns about once in 2 sec. Pulses of 1000-cycle tone at 100% level are recorded at intervals. These pulses are long enough for the supply spool to turn $\frac{3}{4}$ revolution, about 1.5 sec. The pulses are repeated every sixth revolution of the supply spool, and generally ten such pulses are sufficient for measurement purposes.

After the recording, the roll is rewound and put in storage for a definite period of time. At Reeves Sound Studios a period of four hours has been selected as a standard storage period.

Method of Measuring a Print-Through Test

In measuring, filters must be used to eliminate or limit any hum or other noise from the tape machine output at the meter on which measurements are to be made. This meter must have means for quickly changing its sensitivity over a wide range and must have a fast-acting pointer movement.

A bandpass filter effect can be achieved by using the 500-cycle high-pass filter and 2000-cycle low-pass filter of a standard Effects Filter. The V.U. meter of a General Radio Type 1932-A Noise and Distortion Meter is used for the indicating instrument. This meter has interlocking push buttons to change sensitivity and meets all the requirements perfectly.

On reproduction, the print-through pulses can be observed rising above the noise level. With recorded pulses every sixth revolution of the supply spool, consider the first print-through observed as the one following a recorded signal. The next will be the second print-through from this signal. The next will be the combination of third print-throughs from the previous signal and the next one coming up. The next will be the second print-through from the signal coming up. The next, always the highest in value, will be the first print-through from the signal coming up. An example of this is shown in the readings below of an actual print-through test. These figures are all in db below the 100% recorded 1000-cycle pulses.

55½ db—1st print-through after the signal
61 db—2nd print-through after the signal
61½ db—3rd order print-through
58 db—2nd print-through before the next signal
51½ db—1st print-through before the next signal
Note: Noise level was 63 db below 100% signal in this test.

We now have a measure of how much print-through reduction is required, as well as a positive and simple method of measuring.

Many experiments were made with little or no results. These experiments included tape with thicker base, cold storage of tape, recording at lower levels and change of recording bias, using a narrower playback head to eliminate any edge effect and using special tapes.

One method of print-through reduction stood out as being practicable without suffering too much from the "inevitable compromise." This method consists of actually erasing the print-through just prior to the program reproduction at the playback head or at least erasing enough of it to make the remaining amount inaudible. If print-through is caused by inclusion of very easily magnetizable fractions in the coating and is mainly a surface effect, then threshold erase is a solution.

The following paragraphs and tables are the final results of what seems to be a positive method of eliminating trouble due to audible print-through, at least with the Fairchild "Pic-Sync" machines.

Print-Through Erasing

Although the application of some surface erasing seems to eliminate audible print-through, complete tests had to be made to see if any other trouble was being introduced in the reproduction of program material.

In all the tests that follow, the recordings were made in the normal manner described before. In the reproduction of these tests the following changes were made to the Fairchild Machine:

1. The record head plug was removed from its receptacle.

2. The erase head plug was inserted into the record head receptacle. This connects the erase head to the normal record head circuit.

3. A 3700-ohm resistor was added in series with the present 2200-ohm V.I. meter bridging-out resistor for the reading of bias. This allowed a reading of bias to the erase head of 0.5 db which corresponded to a Ballantine VTVM reading of 16.5 v across the erase head and 3.5 v across the 130-ohm resistor normally in series with the record head.

4. The relay coil circuit in the power amplifier chassis was opened so the 14,000-cycle control signal would not be applied to the record head receptacle to which the erase head is now connected. This was necessary to avoid loss of synchronization on playback.

The above changes put what was normally the 69,000-cycle recording bias into the erase head instead. The value of this bias is adjustable with its usual control.

The first test made was to see what happened to frequency response with erasing before playback. A complete frequency test was recorded 10 db below 100% signal level in a normal manner. It was reproduced immediately in a normal manner. Then it was immediately reproduced three more times with 69,000 cycles to the erase head each time. The results are shown in Table I. They

Table I. Frequency Response, in db.

	69,000 cycles to erase head			
Frequency	Off	On 1st reprod.	On 2d reprod.	On 3d reprod.
30	0	+0.1	+0.1	0
40	0	+0.1	+0.1	0
50	0	+0.1	+0.1	+0.1
70	0	0	0	0
100	0	0	0	0
200	0	0	0	−0.1
500	0	−0.2	−0.2	−0.2
1,000	0	−0.3	−0.3	−0.3
2,000	0	−0.3	−0.3	−0.3
3,000	0	−0.4	−0.4	−0.4
4,000	0	−0.4	−0.4	−0.4
5,000	0	−0.5	−0.6	−0.5
6,000	0	−0.5	−0.5	−0.5
7,000	0	−0.5	−0.5	−0.5
8,000	0	−0.5	−0.5	−0.5
9,000	0	−0.5	−0.5	−0.5
10,000	0	−0.4	−0.5	−0.5
11,000	0	−0.5	−0.5	−0.5
12,000	0	−0.6	−0.6	−0.6
13,000	0	−0.6	−0.5	−0.6

Note: Correction applied to all readings so normal playback response shows flat.

show two important things: first, a slight loss in high frequencies (the only compromise found so far); and second, immediate repeated playings have no more effect. These effects can be explained by assuming that the erasing being done is only on the tape surface. The higher frequencies, occupying less depth in the magnetic coating, had a higher proportion of their signal erased, and after the surface is erased once, there is no more effect, at least for immediate repeated playings. Final tests have not been made to determine what happens if this same roll is stored a while and then reproduced again in a like manner.

The above test was repeated using rolls from three tape manufacturers, except that the repeated playings with the 69,000 cycles were considered unnecessary. The results showed no appreciable differences. However, it is quite conceivable that recordings made on another machine, other than a Fairchild, could show a difference. Whether or not this could occur would depend on the record head magnetic field distribution and the resulting ratio of frequency vs. depth of magnetization on the tape.

The next test made was for distortion. An intermodulation signal of 2000 and 100 cycles at a 1:4 ratio was recorded, varying the input level in regular steps. The results in Table II show that there is no change at all in intermodulation distortion with the application of 69,000 cycles to the erase head, either during the first playback or for three successive immediate playbacks. This holds true also for tapes of other manufacturers recorded on the Fairchild machine.

The next test made was to see if output level changes would follow input level changes over a reasonable range. The results of this test are shown in Table III. Appropriate high-pass and low-pass filters were inserted in the playback circuit to limit the effect of noise as far as possible, although some radio-television interference was present. With the application of 69,000 cycles to the erase head the

Table II. Intermodulation Distortion, in %.

Input level	69,000 cycles to erase head			
	Off	On	On	On
−4	1.0	1.0	1.0	1.0
−2	1.0	1.0	1.0	1.0
0*	1.3	1.3	1.3	1.3
+2	1.8	1.8	1.8	1.8
+4	2.7	2.7	2.7	2.7
+6	4.0	4.0	4.0	4.0
+8	6.0	6.1	6.0	6.0

* Normal 100% input level.

1000-cycle output dropped about 0.25 db and the 10,000 cycle output dropped about 0.5 db. This is to be expected from the frequency-response results shown in Table I, as the same roll of tape was used. The second and third successive playbacks with the 69,000 cycles to the erase head again show no significant difference from the first playback under the same conditions.

The above test was repeated with tapes of other manufacturers with practically identical results.

A specific test for the effect on noise level of 69,000 cycles applied to the erase head was not made. However, in all print-through tests the noise level showed no change with the restricted frequency range used.

In trying to leave no stone unturned, any possible effect of a subharmonic of the 69,000 cycles applied to the erase head causing trouble was investigated. As any effect of this sort should show up in a frequency-response test, a recording was made 10 db below 100% level of a very slow frequency sweep up and then down from 6000 to 8000 cycles. This sweep included 6900 cycles, the 10th subharmonic of the 69,000 cycles. The total recording time of this test was 2 min and 40 sec. In playing back this recording with the 69,000 cycles applied to the erase head no significant change in output level was noticed at any frequency.

Table III. Output vs. Input Level Change Linearity, in db.

	69,000 cycles to erase head								
	Variations from reading without 69,000 cycles								
Input level	Playback at 100 cycles 1st	2d	3d	Playback at 1000 cycles 1st	2d	3d	Playback at 10,000 cycles 1st	2d	3d
0*	−0.1	−0.1	0	−0.3	−0.3	−0.3	−0.5	−0.6	−0.8
−10	−0.1	−0.1	0	−0.4	−0.3	−0.3	−0.6	−0.9	−0.9
−20	−0.1	−0.2	−0.1	−0.3	−0.3	−0.2	−0.4	−0.6	−0.7
−30	−0.2	−0.2	−0.1	−0.3	−0.3	−0.3	−0.6	−0.7	−0.8
−40	0	0	+0.1	−0.2	−0.2	−0.2			
−42	−0.2	−0.1	0	−0.1	−0.1	−0.2	−0.6	−0.5	−0.4
−44	−0.1	−0.1	−0.2	−0.2	−0.2	−0.2	−0.4	−0.4	−0.5
−46	−0.1	0	0	−0.3	−0.3	−0.4	−0.6	−0.6	−0.6
−48	−0.4	−0.2	−0.2	−0.2	−0.3	−0.4	−0.4	−0.4	−0.4
−50	−0.4	−0.4	−0.3	+0.1	0	+0.1	−0.1	−0.2	−0.1

* Normal 100% input level.

The last test was to determine the print-through reduction effectiveness of the 69,000 cycles to the erase head on tapes of three manufacturers. Tape rolls A, B, C and D were put through the regular print-through test routine except that two groups of 1000-cycle pulses were recorded on each roll. The first group on each roll was played back with the machine in its normal condition and the second group with the 69,000 cycles to the erase head. The results are tabulated in Table IV. Accepting the figure of 55 db below 100% signal level as being just satisfactory, tapes A, B and D would reproduce audible print-through under normal reproducing conditions and tape C would not. With the application of 69,000 cycles on the erase head, none of the four tapes would reproduce audible print-through.

Table IV. Print-Through and Noise Level, −db Below 100% Signal

	Tape Roll			
	Tape A	Tape B	Tape C	Tape D
69,000 cycles, off	53½	49½	57	52½
69,000 cycles, on	59½	56½	61½	59½
Noise level	65	66	63	63

As a result of these tests, the print-through problem (as applied to production methods) appears to be solved. The only compromise in making this possible is a slight reduction in high-frequency response. This effect is small enough to be ignored, but it can be compensated for in the playback amplifier equalization. Reeves Sound Studios have put this system of print-through reduction in operation.

In conclusion I wish to acknowledge the helpful assistance of Raymond E. Biondi, Homer H. Elder, Charles E. Campbell and Richard J. Vorisek of Reeves Sound Studios, Inc.; Ernest W. Franck and Edward Schmidt of Reeves Soundcraft Corp.; and Wentworth D. Fling of Fairchild Recording Equipment Corp.

A Scientific Approach to Informational-Instructional Film Production and Utilization

By C. R. CARPENTER and L. P. GREENHILL

This is a report on a research program sponsored by the military services for the past four years, dedicated to production of 16mm informational films.

THE EQUIPMENT of the motion picture and television industries has been developed to high performance standards and there is continuing effort to make still further improvements. These improvements are the result of scientific research in such fields as physics, chemistry, optics, electronics and engineering. Research and development have been concentrated mainly on technical equipment and its performance.

The primary function of motion picture and television equipment is to communicate from some people to other people. Therefore, the men who use this equipment must deal with human factors which are even more complex than the electronic and optical processes used in recording and reproducing ideas or information on films or television.

Motion picture and television engineers, regardless of their specific technical jobs, are working within a matrix of human factors, processes and variables. The study and control of the interaction between equipment and people, is an area of applied psychology which has been termed Human Engineering.

When we look at the field of communication as a whole it is clear that:

1. We have made great progress in developing mass communication equipment.
2. We have made little progress in scientific research on the psychological processes of communication.
3. Technological developments are far ahead of the human engineering developments.

We have developed wonderful machines and systems for communicating, but we are uncertain how to use them to the best advantage for worth-while purposes. We can communicate with millions of people in this and other countries,

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but we are not sure what should be communicated. Even when we know what to communicate, we do not have confidence in our knowledge of methods for doing this effectively. There are challenging social problems which the communications industries might aid in solving with their available tools, but these tools are not being applied effectively to these problems. The *science* of human engineering as applied to radio, motion pictures and television is in its very early infancy.

We believe that this lack of development is due in large part to the fact that the *human variables* in mass communications have not been thought of as a legitimate and important field for scientific research and development. Consequently this kind of research, both basic and applied, has been grossly neglected. Resources for this kind of work have not been made available: men with adequate competencies have not been trained for the job; suitable research laboratories have not been built.

It is encouraging, however, to observe that there is a growing interest in the human aspects of communications. A few universities are establishing departments of communication. Government and military research organizations are supporting and encouraging research in this field. It is being realized also that "audience research," though important, is not sufficient for learning all we need to know in order to apply intelligently the potential powers of the communication industries to urgent problems of our society: problems of information dissemination, of group and class tensions and conflicts, of instruction necessary for people's adjustment and survival in a complex world of successive crises.

Should it not be that the *primary mission* of the communications industries is that of *training*, *instructing* and *informing* people, and that the amusement and entertainment of people is the secondary mission of these great industries? If this emphasis were to be arranged, these industries would assume a place of paramount significance in our world.

Importance for Engineers

The foregoing considerations are of great importance for motion picture and television engineers. New nonentertainment uses for the mass media are making up a large part of current film production. The need for extending the application of sound motion pictures and television is a matter which challenges promotion, financing and business organization. It is not mere speculation to visualize the possibilities of nonentertainment communications expanding to the point where the volume of business for this purpose will exceed the volume of business for entertainment purposes.

The engineer has a vested interest in the *effects on people* of the programs which he helps produce. For example, the strength of impact of a program calculated to sell products and the ways in which this impact, over a period of time, changes the behavior of audiences may determine whether or not the program will be continued. The engineer's understanding of human engineering factors can have a vital influence on that impact. Furthermore, the intelligent communications engineer has the right and the responsibility to be concerned with the effects of programs on people. If both he and the medium are to have integrity he certainly cannot allow himself to be a mere automaton of the communications machinery. The control of the mass communications industries can be centralized and authoritative or the control can be democratic; that is, it can be dispersed to conform to democratic management which will permit the individual exercise of judgment and knowledge by the engineer in determining the final influence of a motion picture or television program.

Thus, both from the viewpoint of business and of professional-social responsibility, the engineer has a vested interest in the effects of programs on people.

THE INSTRUCTIONAL FILM RESEARCH PROGRAM

The Instructional Film Research Program of The Pennsylvania State College is one limited effort to learn more about the human factors and the ways they interact with the sound motion picture as a medium of communication. The Program is sponsored by the Departments of the Army and the Navy through the Special Devices Center, Port Washington, L.I., N.Y.

The objective of the Program in terms of the controlling Task Order is to discover facts and principles which will improve the effectiveness of films for the rapid training, instruction and education of large numbers of people.

It is the central responsibility of the Instructional Film Research Program to apply and test the application of learning principles to instruction by motion pictures, as well as to try to develop new principles and procedures for increasing the effectiveness of film-mediated instruction.

Since its beginning in 1947 the research of the Instructional Film Research Program has been limited mainly to the instructional and informational film. The entertainment film has been of interest to the extent that it may involve processes which can be used to improve instructional and informational films.

Research Methods and Procedures

There is nothing obscure or mysterious about the methods and procedures being used in this research. Essentially the methods consist of applying and adapting the general principles of scientific research to the content and arrangement of stimulus variables in instructional motion pictures. Research is done also on the responses of individuals to these film variables. In general, the problem is one of determining the effects on target audiences of varying the streams of stimuli-events channeled through the sound motion picture.

Theoretical concepts are used at many points and in many ways. Existing and generally accepted theories of learning may be tested in a film context. Theoretical hypotheses may be stated as settings for research projects. Theoretical outlines may be used to guide the direction and to help maintain the balance of effort of the continuing program. Finally, theoretical statements may be employed to aid in summarizing and interpreting results. *For the practical man there is nothing so practical and useful as sound, tested theory.*

Usually we proceed by defining the variable which we wish to study in a film. For example, we may define *rate of development* (the screen time devoted to each phase of the action) as the variable to be studied. The next step may be to produce several film versions, preferably three or more, which differ from each other *only* with respect to *rate of development.* These different versions of films are then shown to matched groups of subjects, the amounts of learning are measured, and the results are compared. Thus, we learn which *rate of development* is most effective for the experimental film when used with a particular audience.

Several variables may be combined in a single version. For example, *rate of development* may be combined with controlled *repetition.* By producing systematically a number of experimental film versions, some with and some without specified variables, it is possible to determine the relative contribution of single variables to learning, and also to determine how the variables interact with each other and with the audience. Some variables may be additive in their effects while others may interfere with each other.

An experimental film *variable* is a single, definable, controlled characteristic of a film, such as rate of development, repetition, "subjective" camera

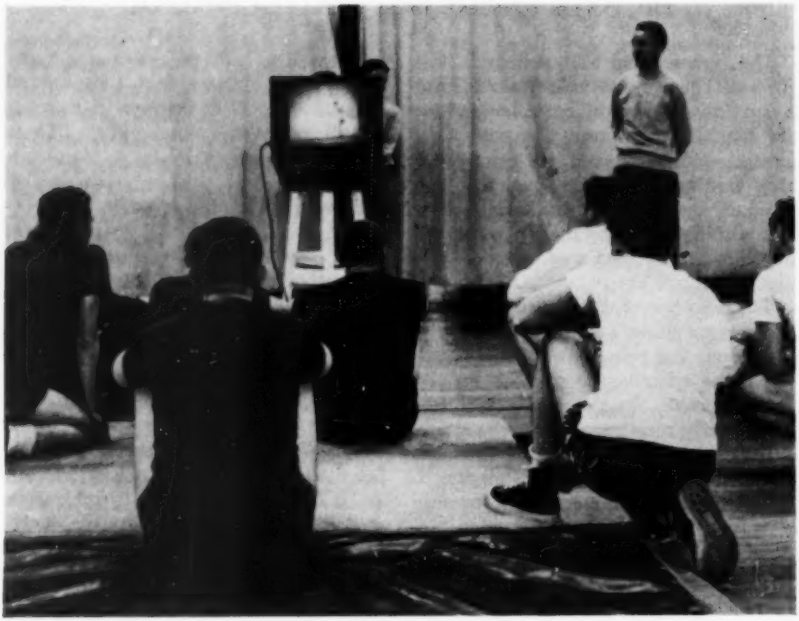

Fig. 1. Class learning tumbling skills from film loops and daylight projector.

angle or level of difficulty of materials presented.

An experimental film *version* is a film which contains the controlled stimulus material (one or more variables) which is presented to a test group of subjects. A number of such film versions varied in systematic fashion may be required for solving a defined problem.

The design of experiments for testing the relative effectiveness of several variables is somewhat complicated. However, there is one clear, simple and important concept, namely the effects of a variable are measured in terms of the responses of the individuals in the test population. For example, if the film's purpose is to teach facts, the central question is: How does the experimental variable contribute to or interfere with the learning of the presented body of facts? The measurement is made by informational tests, usually of the multiple-choice type. The objective is to measure the amount of learning and retention which is the result of the film, and furthermore to measure the increment of learning which results from the presence in the film of the one or more experimental variables.

With experimental films which have as their objective the teaching of performance skills, essentially the same procedures are used, except that actual performance tests are given. The basic questions are: Does the film actually teach the performance of a skill, and how much of this teaching is the result of the experimental variable? Does a film which is supposed to teach first aid to the injured actually teach trainees something in addition to what they already know? If one of the versions contains the experimental variable *showing errors to be avoided* in giving first aid, is this film version superior to one which does not include the variable *showing errors to be avoided*? With

performance-type films the desirable thing is to measure the *actual performance* of the trainees before and after filmic instruction, i.e., to determine whether the performance of a group trained by a film under specified conditions is superior to that of a control group, i.e., an equivalent group not subjected to the filmic instruction.

In brief, the emphasis is on measuring actual changes in the behavior which results directly from the stimulus value of the film and its controlled characteristics.

Research Projects and Results

The Instructional Film Research Program has formulated more than sixty research projects. These projects may be classed into four groups: (1) the development of new research equipment, and testing of new equipment and methods of using it; (2) research on films produced for teaching performance skills of various kinds; (3) research on films for teaching factual information; and (4) research on films for changing attitudes, opinions and personal orientation.

These four general groupings of projects which have been undertaken by the Instructional Film Research Program include many phases of work related to both the producing and the using of sound motion pictures. Many of the research projects are also closely related to basic problems of radio and television as well as to the sound motion picture. Regardless of the research problem or the type of materials used, the basic requirement is *to discover variables of communication which produce desired changes in the behavior (perception, learning, motivation, actions, etc.) of defined target audiences.*

Development and Testing of Equipment

A. The Classroom Communicator and Film Analyzer systems[1,2] have been planned and developed primarily as research tools appropriate to the problems being attacked. However, this equipment may be adapted for a wide range of uses in practical situations where reactions of people to film, radio and television programs are required. Figures 1 through 4 show the general features of these systems.

The Classroom Communicator and Film Analyzer when used together are capable of doing the following:

1. Immediately recording discrete responses of individuals in audiences of up to 40 people in size.
2. Continuously recording reactions, decisions and judgments of individuals while programs are being presented.
3. Rapidly informing either individuals or the group as a whole of the results of their responses, i.e., correctness or incorrectness of choices.
4. Providing summated numerical records of scores for individuals.

B. The Tele-kit. Research was done last year (1951) on field-testing and developing methods of use for the Tele-kit daylight 16mm projector along with the T.A. Repetitive Impact continuous film magazine.[3,4] The equipment for testing was made available to us by Capt. William C. Eddy of Television Associates, Inc.

The purposes of one series of experiments were to determine the functional characteristics and limitations of the equipment, to develop methods and procedures for using the equipment, and to test the amounts of learning of skills induced by methods of instruction using this equipment in comparison with other methods of instruction. Using the film-loop projector alongside the training area, and providing for interspersed practice was found to be a very effective method of teaching physical performance skills.

Further research[5] was conducted at The Great Lakes Naval Training Station to study the following problems relating to the use of the Tele-Kit and the film loop:

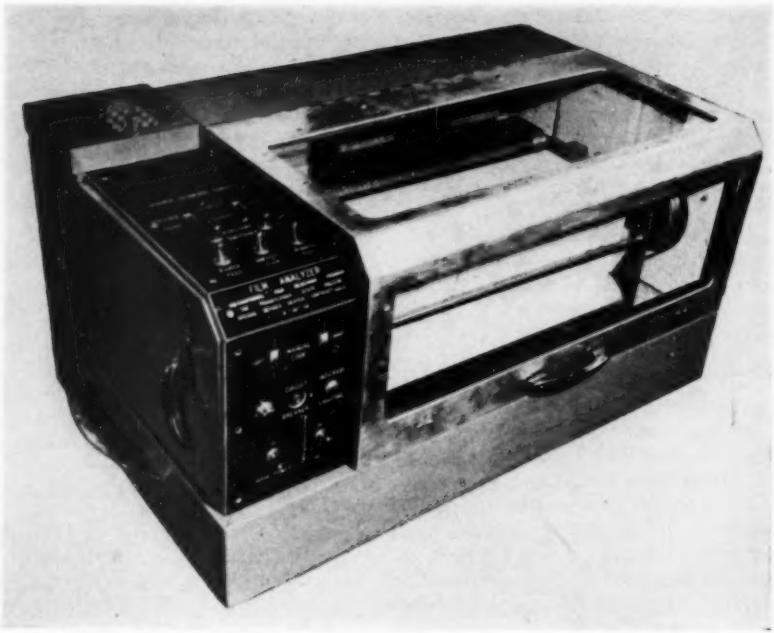

Fig. 2. Film Analyzer Recorder for continuous or intermittent recording of audience responses

1. The effects on learning of various screen-viewing distances and angles. The distances studied ranged from 4 to 24 screen widths, and the angles of viewing the screen ranged from 0° to 60°. The screen size was 12 in. × 18 in.

2. The effects of ambient illumination on learning from a film projected on the "daylight" rear-projection screen. Tests were made under normal room-lighting conditions and in a darkened room.

3. The effects of repeated viewing of a film loop.

4. The relative effectiveness of films having "slow" and "fast" rates of development.

5. The effects of having the trainees practice an assembly task while viewing the film loop.

The task taught by the film was the assembly of the breech block of the 40mm antiaircraft gun. The effects of the film variable or the methods of presentation variables were measured by testing the *actual performance* of the subjects in assembling the breech block immediately after the film showings. About 2000 Navy trainees were used as test subjects.

Preliminary analyses of data show the following results:

1. Viewing conditions. The optimum area for viewing the daylight projection screen lies within a total angle of 60° (30° on each side of the projector axis). This area extends out to a distance of 16 screen widths from the screen (24 ft for the 18-in. screen). Of the men seeing the film from within this area, approximately 75% succeeded in assembling the breech block. Thirty to forty individuals could be seated in this area.

An area of reduced learning effectiveness in which approximately 50% of the

Fig. 3. Instructor's Console of classroom communicator (Veeder-Root Bank of Individuals' Score Summators to right).

men succeeded in learning the task extends around the optimum area described above to a maximum total angle of 100° for daylight viewing and 120° for viewing in the dark. This area of reduced learning extends out to a maximum viewing distance of 24 screen widths along the central projection axis.

2. Repetition. Preliminary results of these tests for the repetition variable are as follows: repetition of the film by the film-loop method aided greatly in teaching trainees to assemble the breech block. Two showings were better than one showing, and three showings were significantly better than two, i.e., with repetition more and more men were able to assemble the breech block. It may be assumed that more repetitions would: (1) teach more of the trainees to reach the minimum performance requirements, and (2) improve the assembly skills of trainees beyond the minimum performance requirements. It may be assumed also that a level of diminishing returns of repetition relative to learning would be reached. Training requirements should determine the number of repetitions used.

These tests provide evidence for the soundness of the "repetitive impact training" method and the usefulness of equipment which makes this method relatively easy to apply. By repeated showings of *well-prepared* short units of training films, predetermined training standards can be achieved.

3. Rate of development. A film which was produced with a *slow, deliberate rate of development*, i.e., the showing of an action or sequence of actions with more screen time than is normally used, was much superior to a film with a fast rate of development. Results show that repetition amplifies this advantage and that the disadvantages of rapid, heavily packed or concentrated films cannot be entirely compensated for by repeated showings.

4. Participation. Practice by the trainees of the performance at the same time as it is being shown on the screen aids learning of the skill when used with the *slow-development* film, and reduces learning when used with the fast-development film. It can be generalized from these and other findings[6,7] that in order for concurrent *practice* of a skill being taught by a film to be effective the film must have a sufficiently slow rate of development or allow time between sequences in order to provide favorable conditions for practice or participation.

These field tests of the actual effectiveness of the Tele-Kit daylight rear projection equipment and the T.A. Repetitive Loop magazine demonstrate the kinds of functional testing that can be done with many other kinds of film, radio and television equipment. Such field tests can be used to establish the "operational characteristics" of equipment in terms of what this equipment can actually be expected to do to people, and not in terms of opinions about what the equipment might do when people are involved. For example, there is a general standard that the maximum screen-viewing distance should be limited to six times the screen width. Field tests in terms of effects on learning a skill show that for the film and projector used the effective viewing distance extends to 16 screen widths from the screen but that beyond this distance there is a substantial decline in the subjects' learning. These findings have important implications for television viewing.

Film Variables Positively Related to Efficacy of Instruction in Performance Skills

Four major projects of the Instructional Film Research Program have isolated eight variables that aid learning. In other words, films with the following eight characteristics are likely to be more effective in teaching performance skills than films which lack these characteristics:

1. Medium verbalization. Tests have shown that the optimum number of words in the commentary should range between 100 and 130 words per minute of film.[8] Fewer rather than more words are probably desirable. When complex pictorial material is shown, or when it is necessary to use new terms and words, repetition of these new concepts should be employed.

2. Audience participation. Practice of the skills at the same time as the film is being shown aids learning greatly if favorable conditions for practice are provided.[7] These can be achieved by producing films with slow rates of development so that the action on the screen can be followed *and* the practice carried out without loss of attention to either. Or, short sequences of films may be shown, followed by opportunities for practice, repetition of the same sequences, or the presentation of a new element of the skill to be learned. Portable projectors, daylight screens and television tubes make it possible to present audio-visual instruction to trainees in actual work situations, e.g., on assembly lines. Thus skills can be taught to trainees in situations where they can learn with expert guidance from the film as they practice. When these methods are applied great economies may be made by reducing the amount of trial and error in training, by savings in man hours of both trainees and instructors, and by increasing the *amount of transfer of learning* from the training situation to the actual work situation.

3. Slow rate of development. It has been found to be advantageous to use what might be called a slow rate of develop-

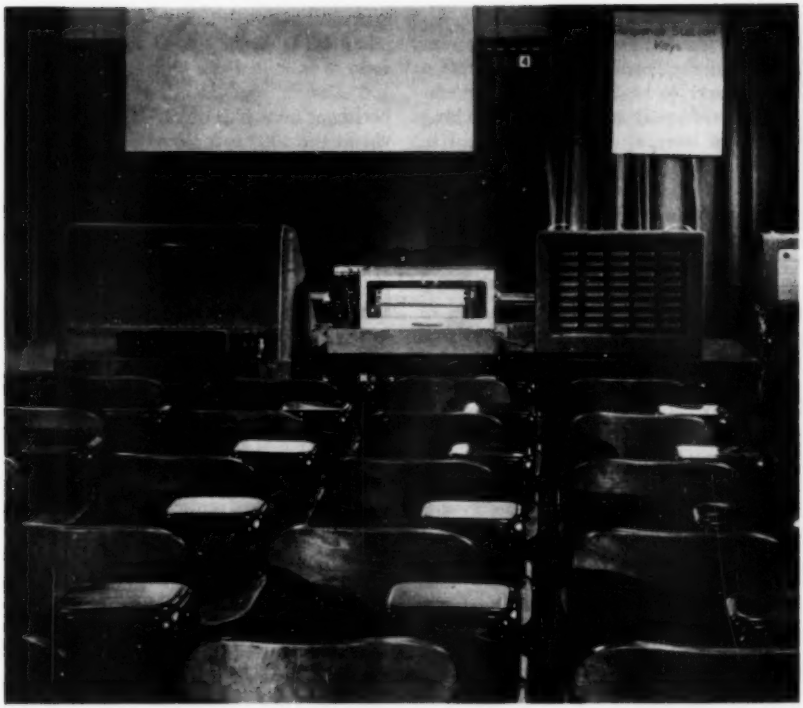

Fig. 4. Communications Test Room showing: Instructor's Console; Film Analyzer; Veeder-Root Bank for summing scores; correct-answer, signal-light panel (on wall); and response stations (on desks).

ment of the subject being presented.[8] This requirement is especially important in elementary introductory training. Clearly, optimum *rates of development* or rates of pacing a film will vary depending on the complexity of the skills being taught, the abilities and previous experience of the trainees, and other factors such as the conditions under which training is being done. It is impossible, therefore, to state a simple rule of thumb. Pacing or development rate interacts with repetition. Repetition may, in part, compensate for the inadequacies of films which "move" too fast. It would seem on the basis of inspection and testing of large numbers of training films that those currently being produced are more often *too fast* in development rather than *too slow*. The abilities of trainees to perceive and learn from a film are generally overestimated by those of us who produce films.

4. Repetition. Repetition has been accepted both in theory and practice as a necessary condition for learning. Sudden learning ("insight") without trials, errors and successes is an exceptional occurrence. The factor of repetition has been accepted and used not only in educational procedures, but is recognized and applied in journalism, advertising and the arts.

The results, therefore, of gains in learning or acquisition of a skill as a consequence of the repetition of film presentations were to be expected.[5] The employment of *repetition* in films for teaching skills can now be recommended with confidence.

There are, to be sure, many unanswered questions: How can the variable of repetition be employed most effectively? How many repetitions are desirable for a particular training job, with a specific group of trainees, in order to achieve a given level of training? How is repetition to be used and yet monotony and lack of interest avoided? How can introductory and summarizing sequences be used to repeat and reinforce instruction? How can repetition be *varied* so that more *generalized* training rather than very *specific* training will be the result? Some of these and other questions must be answered for specific kinds of training; general rules have limited use. This does not negate the proposition that repetition increases the effectiveness of a training film, whether simple repetition of the film as a whole or *internal repetition with variation* is used. It is surprising in this connection that more use has not been made of this simple principle of repetition by producers and users of training films.

5. Showing errors to be avoided. Is it desirable to show errors of performance in training films? The results of Jaspen's experiments[8] indicate that errors when shown aid learning of the required performance provided the error or wrong way is clearly described as an error to be avoided and differentiated from the correct method. The trainees must be taught — shown and told — what the errors are and how to avoid making them. It would appear that "negative training," i.e., trainees performing incorrectly rather than correctly as a result of seeing the errors, is a consequence of incomplete training in the discrimination of errors. It might be mentioned here that good coaching usually involves directing the learner's attention to his mistakes. *The simple rule is to show clearly errors to be avoided in a performance.*

6. Camera angle. Roshal[6] did an experiment on a pair of variables — the 0° versus the 180° camera angle. In other words the training task was photographed from the viewpoint of the performer (0° angle) and from the viewpoint of the observer (180° angle). The film which was photographed from the viewpoint of the performer proved in actual tests to be superior to the film photographed from the viewpoint of the observer. From this and related studies a simple rule can be formulated: In skills-training films wherever possible *show the job exactly as it will be seen by the trainee when he performs it.*

7. Personalized commentary. Zuckerman[9] has studied some of the characteristics of commentaries in training films. He found that the direct personalized form of address proved to be better than several other forms of address. In other words, addressing trainees as "you" and otherwise personalizing the instructional commentary had advantages. In addition, the timing of the commentary to the visuals may have an important influence on learning. In teaching a complex skill, alerting the learner to the action to appear on the screen by having the commentary slightly lead the picture was found to be helpful.

8. Motion. Results of experiments tend to confirm the widespread belief that in teaching skills involving action, motion pictures are superior as instructional materials to successive stills of the action.[6] Where the *crucial* cues to be learned are *action* or movement cues, then a *motion* picture representation is superior to those methods which do not represent the complete action. This raises a basic question: What are appropriate training tasks for motion pictures or television? The suggested answer is that those training tasks which involve crucial and complex action are appropriate to those

media which have capabilities of showing such action.

Variables Related to the Efficacy of Informational Films

1. Idea density. We have approached the problem of the *amount, rate* and *difficulty* of materials presented by means of films.[10] This problem arises out of considerations of the following questions: How much information can be presented effectively in a given period of time? How does the level of difficulty affect the learning of this material by given audiences? What treatment of a given body of information most effectively carries the informational content to be communicated? For example, is the story form of organization more or less effective than a straight expository presentation, or is an organization with a prominent outline which is repeated and made very clear by titles more or less effective than a smooth uninterrupted development?

The research on these problems is not yet complete or definitive. However, we have developed a strong conviction that for a single film there is an optimal amount of information for a given audience or trainee population. We are also convinced that many instructional sound films are overloaded with information, i.e., more material is presented than can be effectively learned by the audience.

2. Introductions and summaries. We have made a rational analysis of the functions served by film introduction and summary sequences.[11] Tests have shown that introductions and summaries may either *add* or *detract* from the instructional value of films depending on their adequacy. Poor, sketchy and ambiguous introductions and summaries may reduce the effectiveness of the film. On the other hand, cogent, clear and well-integrated introductions and summaries increase the effectiveness. These parts of a film may be used to provide much needed *repetition, review* and *emphasis.* They can also be employed to set learning goals or purposes for trainees, to clarify organization and to emphasize the importance and practicability of the film's contents.

3. Pretests and knowledge of results. We have found that pretesting trainees on the information to be learned increases the amount of the learning.[12] Also, when practical, it is worth while to inform trainees of the results (both errors and correct responses) of their attempts to master the learning tasks presented by means of sound films.[13]

4. Color vs. black-and-white films. We have preliminary findings which suggest that most learning tasks may be presented equally effectively by monochrome or color films.[14] Color films have an advantage when crucial cues for learning depend on color. If the thing to be learned (such as the identification of flowers, kinds of wood or geological specimens) depends heavily on color, then the discriminative learning may best be done from color films. However, it would seem there are subtle and, as yet, unmeasured distractive effects involved in instructional color films.

5. Special effects. Studies suggest that devices used in films solely to gain attention, such as "stop-motion" shots of still objects, pictures of pretty girls, arresting sounds or noises and unusual angles used purely for their striking effect, have little or no influence on improving the learning scores of trainees. Such devices do not seem to justify the effort and expense of including them.[15]

An experiment was recently completed on the effect of opticals on learning from instructional films.[16] Three versions of each of two different informational films were prepared. One version of each film had no opticals (straight cuts all the way through); a second version had fades only between major divisions of the film; and the third version, which was the film as originally produced, had a liberal number of fades, wipes and dissolves used in accordance with the generally accepted "rules" for using these effects. The learning results showed no

significant differences between the versions.

6. Use of films exclusively. It has been shown repeatedly[4,6,7,8,17] that good sound films can do an instructional job without the aid of highly trained instructors. Thus, adequate films can release instructors from much instructional routine and give them time for instruction of the kind which cannot be done by films, e.g., personal attention to individuals, or applying instruction to immediate specific situations. Furthermore, film-to-trainee instruction puts responsibility for learning directly on the trainee where it ultimately must rest and reduces the responsibility which the instructor must carry.

7. Practice in learning from films. Finally, some of our results strongly suggest that students *learn* to *learn* from films.[18] In other words, practice in learning from films increases the facility with which students acquire information from subsequent films.

PRACTICAL IMPLICATIONS

1. In the production and use of instructional and informational films full cognizance must be taken of the characteristics, abilities and limitations of the people in the audiences who are to be instructed and informed. In order to check whether a film is suitable for the characteristics of the target audience and whether it achieves its objectives, it is believed to be necessary to conduct "proving-ground tests" on the effectiveness of the film with samples of the intended audience.

2. Tests of instructional efficacy or learning need not be delayed until films are completely produced, but they may be conducted at several stages during production and prior to release and distribution.

3. No single film can be entirely suitable for an audience with a wide range of backgrounds and abilities; therefore, multiple versions of films which permit great flexibility of use are desirable to meet the needs of different audience levels.

4. Existing methods of film production and utilization can be greatly improved by applying psychological research methods and results. By using suitable films as the main medium of training, high levels of effective instruction can be achieved.

5. Research on the functional characteristics of sound motion pictures and television, as these interact with audiences, is equal in importance to research on equipment and technical processes. The human engineering approach would seem to be essential for further important advances in the communications industries.

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Film Production Principles— The Subject of Research

By KEN KENDALL

The considerable number of technical and progress reports issued by the Instructional Film Research Program at The Pennsylvania State College for 1948–50 are reviewed. The results of the research are reported and assessed particularly as to their possible meaning for other production as well as for instructional films.

As though by an overnight snowfall, the face of the art of communication has been changed. By comparison with what is coming, television is reactionary, a mere extra convenience in a new science. The scope of this revolution has even changed the meaning of the word "engineering." This is the story.

Originally engineering meant the art of managing an engine. Yesterday it came to mean the science of making matter and power useful to man. Today it has come to mean a new science, the science of making man useful to man and machines fitted to man. This is called Human Engineering.

To do anything with man, to use him in any way at all we require a tool. That tool is communication. Human Engineering can only be as effective as the completeness of the mastery of the mechanics of that tool. Thus the engineer's striving toward better communications has now shifted its emphasis. The old objective of higher fidelity is now a by-product of the art. The old purpose was to carry a message — an audio-visual message right up to the point of impact on men's senses. The new purpose today is to have communications go behind the eyes and ears and include the mind, the whole man and his behavior. It is now required of good communication engineering that the message be recollected and used by the recipient.

It is worth while thinking of this in terms of money — of communication costs. The revenue-producing motion picture now has a lusty young competitor. It is the sponsored picture. A documentary, an advertising film, a television program, a teaching or training film — any and all of these may be sponsored and shown without a box-office purpose in mind. There are other purposes.

Yet these two masters, the box office and the sponsor, require very different production psychologies. This is be-

A contribution, made at the request of the Society, by Ken Kendall, The National Film Board of Canada, John St., Ottawa, Canada.

cause each has a different way of getting back its money.

Box-office returns depend on fleeting entertainment values. Memory of the picture is not too important. In fact, should viewers forget their first experience and see the show again the returns would increase.

Sponsors, however, seek to purchase pictures whose details will be specifically recollected. With a sponsor, the financial justification of a picture depends on this, and on how well the message is recalled, the information used or the suggested course of action followed.

Inevitably, therefore, the engineering evaluation of the system and the planning of film or television production cannot be divorced or isolated steps in a chain of events. The costs of transmission fidelity now share in the balance with the evaluation of the fidelity of human reactions. Like it or not, picture producers, wherever engaged by sponsors, are now working in a branch of human engineering and must follow the engineering approach of understanding and putting to use the findings of scientific research.

Picture producers and scientific researchers are apt to view any work wedlock between themselves with mutual horror. Artists, writers, musicians and producers have long told the world that all science is a shackle, while research groups test everything until it yells for mercy. Again, most researchers try hard to withhold their findings until proof is completely unchallengeable, a point at which it has usually become totally incomprehensible to the layman.

The researchers say, "Research must be complete before it can be divulged." Others argue, "But think! Research is never complete. The whole of human progress stands on imperfect knowledge, or incomplete but continuing research."

Of extreme news value to the motion picture and television field is the fact that one of the human engineering research groups has decided to allow its interim findings to be reported. The sponsorship of this research is a joint one: the United States Departments of the Army and the Navy have a human engineering project conducted under contract by The Pennsylvania State College.

The following summary is digested from reports covering over sixty research projects in various stages of development. These concern the elements of effectiveness in films which alter audience behavior. A defense project, this research sought to measure the amount of learning produced by special films used in the training of thousands of men. As in all valid science, opinions and judgments not based on test results have been meticulously excluded from the findings or, in some cases, stated only tentatively.

Concerning the Research Method

Skip this section if you wish. It concerns the question of the validity of the new findings. Experienced producers have and will take exception to them. They feel that research teams are not "showmen." Are such teams, they ask, qualified to judge? Similar questions may rightly be expected from all who are connected with motion picture and television production.

The heart of this challenge rests squarely on the matter of the opposed purposes of box-office and sponsored motion pictures. The greater part of the producer's "expert opinion" as to the desirable factors in the production of motion pictures has been based either on box-office returns, or on audience entertainment reactions in theaters, or both. All such evaluation tends to measure only the entertainment value at the time of seeing the picture.

But all sponsored pictures are fundamentally informational; therefore the sponsor (unconsciously or otherwise) is buying a package of "learning" which he wishes the audience to accept and retain. Thus the picture industry's

evaluation of entertainment elements is not relevant to efficiency of informational films.

For such reasons, scientific research into the dynamics of learning from films has had to start from scratch. The measured actual behavior changes in individuals exposed to informational films have formed the basis of all the findings. As with all valid science, the expert opinions of those in the art are held to be unreliable until independently confirmed by actual tests.

This does not mean that the experience and judgment of experts have been excluded from this research program. The number and caliber of learned people connected with the project are formidable indeed. A later section of this paper gives a partial list of the advisers, consultants and researchers who are or have been involved in this project.

The project, called "The Instructional Film Research Program," is under the direction of Dr. C. R. Carpenter, Professor of Psychology, The Pennsylvania State College; and Mr. Leslie P. Greenhill is the Program Coordinator. The scope of this work is shown by the following approximate outline of the personnel and physical facilities used to date:

Personnel

Advisers and consultants	19
Researchers and associates	33
Engineering and development staff	9
Film production staff	5
Joint military advisory body	7
Cooperating university divisions	7
Unit audience (instant reaction)	40
Other unit audiences, average	70
People used in experiments, approx.	50,000

Tools Used

Special daylight projectors.

Combination workrooms with concurrent projection facilities which enable instant putting into practice of film-taught skills.

Special small projection theater.

Complete instructor or researcher public address facilities enabling dual film and personal instruction to take place.

Special repetitive impact machines.

Special "classroom communicator" or computating multichannel audience reaction machine.

Special "film analyzer" polygraph or synchronous and continuous recorder of audience reactions, decisions and judgments.

Commercial "Pressey Teach-Test" device.

Testing facilities enabling films in production to be tried for efficacy on sample audiences.

Separated audio and visual channels, permitting audio teaching impact versus visual teaching impact to be measured separately and together.

Three-dimensional film facilities; use of color film.

Complete production of experimental films in which the various elements influencing learning can be segregated and tested.

78 special experimental films produced by IFRP for this research ranging from 2 to 30 minutes in length to fit the needs of twelve of the projects.

A number of existing films modified to meet the requirements of other projects.

Clerical system to handle individual viewer recollection fidelity over specified time lapses.

Computing machines for statistical evaluation of the research measurements.

Research Trends

Starting with 45 original research projects (see list at the close of this report) the program to date has formulated and undertaken over 60 research projects. They can be classified into four main categories:

1. Research on the governing factors of films which are expected to change the personal attitudes of the viewer. This attitude change includes opinions, values, beliefs and resulting actions which may be found to last in a given person.
2. Research on the governing factors of films which are expected to impart concepts, facts and principles to viewers.
3. Research on the governing factors of films which are expected to impart skills and arts to viewers.
4. Research on the development of research tools for this new branch of human engineering.

This outline of the Instructional Film Research Program should be appraised against its purpose. Sponsored by the U.S. Department of Defense through the Human Engineering Branch of the USN Special Devices Center, this project has been a specific inquiry into the factors controlling "rapid mass learning." The results have disclosed exact information about the processes (production concepts) which effectively influence human behavior through film or television. Here are the findings:

Film and Video Production Principles Revised by Research Results

Like radio and the press, film and television are transmission devices only. The media of communication are the symbols used, be they words or pictures. Loose thinking has confused this matter so much that so-called research has been directed to establishing which transmission device, radio, television, film, etc., possesses the greatest audience influence. Thus the question of *fidelity of transmission* has been confused with *fidelity of learning* to produce dense clouds of meaningless statistics and much frustration in production craftsmen. Certain definitions in regard to communication symbols have been established and they can be briefly reviewed to advantage here. (*For brevity, the word film is extended to include video.*)

Music is a symbolic form. It articulates concepts frequently difficult to express in language or in photographs. It symbolizes moods and feelings, emotions and tensions. The fact that we cannot always name the mood, emotion or tension conveyed by music is in itself evidence of the symbolic character of music, and of its ability to communicate meanings which are not verbal.

Language on the other hand is a symbolic vehicle of thought and of reason. It is an instrument of naming and conceiving objects and of combining and manipulating concepts and propositions. Language is also the vehicle by which higher intellectual processes are carried on.

Photographs are direct symbols of an elementary or literal type acting as a record of a visual experience.

Motion pictures combine all three of these symbolic forms. It is from the use and integration of these symbolic forms and from their richness in cues to concepts *already formulated by the viewer* that motion pictures derive their enormous potential power to influence human behavior. Thus, while all communications are made by means of symbols, motion pictures are, perhaps, most complicated in this regard.

This complexity of symbolic medium, when considered in film production, gives rise to the following rule. The photographer or producer must actively exclude the mere "literal record" aspect of his science. Each picture must concentrate on communicating its *meaning-evoking content.* This means that every effective shot or picture must have a specific symbolic meaning. This inner meaning which is "seen" by the script writer or photographer must also overlap the specific experience history of the

intended viewer. No significant or lasting recollection is created unless these two considerations have governed the film's production. And of these two, the question of the overlap of the real experiences of the viewer is most frequently apt to be neglected. The point most often forgotten is that what is obvious to the expert or film producer may be anything but clear to the viewer.

Learning Accelerators Found Effective for Films

Factors Related to the Effectiveness of Films for Teaching Performance Skills

So far, 13 factors involved in film production concepts for teaching skills have been the subject of research. They were tested to find which of them positively improved the learning which results from seeing a film that is intended to teach the audience *how to do* something. The factors which have been tested are as follows:

1. Level of verbalization.
2. Explanation of "how it works."
3. The use of technical or specialist terms.
4. Audience participation.
5. Condensed or succinct treatment of the subject.
6. Rate of development of subject matter.
7. The showing of errors to be avoided.
8. The effect of several showings to a viewer.
9. The effect of different camera angles.
10. Effect on learning of motion versus still pictures.
11. Showing the hands of the operator in a film demonstration of a skill being performed.
12. Effect of personal reference in the commentary.
13. Effect of various time relations between verbal instructions and picture.

Of these thirteen factors which are called "variables" by the researchers, those which follow proved to have a positive and most significant influence on the effectiveness of films designed to teach new skills.

1. *Verbal level.* The amount of commentary used to describe the action affects the performance of the viewer. The amount, as measured, rises in efficiency slowly up to 100 words per minute of film and falls as gradually beyond that level. Effectiveness is down by 25% at 40 and at 140 words per minute of film.

4. *Participation.* Audience participation or practice proved to be most effective as a utilization device under suitable conditions. The rate at which the commentary and picture presentation is developed controls this element. Rapid development plus participation acted *against* learning and retention. Slow development which allowed time for the viewers to watch the screen and practice the skill helped learning considerably. An alternative to the slow rate of development is the use of a medium rate of development with opportunities to practice *between* film showings. It was noted that most instructional films used verbal and visual development rates common to theatrical films. These rapid rates were found to be the least effective in promoting viewer recall and performance.

6. *Rate of development.* A slow rate of development is a most important factor in making a film effective. New information in films should be covered pictorially at a speed which is appropriate to the abilities of the viewer. The customary practice of present production is far too fast a rate of development.

7. *The showing of errors.* The showing of common errors or faulty methods to be avoided increases the instructional value of a film. The "right and wrong way" is a most potent film device pro-

vided errors are made explicit and clearly shown as errors.

8. Effect of multiple showings. Repetition of the film demonstration materially aids its impact on the viewer. It is recommended that the film itself incorporate a repetition of basic sequences, perhaps with slight variations. (A suitable film, using slow development, inbuilt repetition, and right versus wrong methods was found to be effective in teaching 98% of Navy trainees how to do a gun assembly task. A single showing and *no other instruction* was used.)

9. Camera angles. On the basis of the tests, it has been shown that learning of a new performance improves as the film visualization approaches the representation of the viewer himself performing the act. Thus a training film is most effective when a zero degree camera angle is used. The usual "position of an observer" or 180° camera angle was shown to be less satisfactory.

10. Motion versus still views. The communication and teaching of action becomes effectively transmitted when the film shows all the *movements* involved in the doing of the new task. A series of static shots which show various steps in the action has been found relatively less effective in the teaching process.

12. Personal references in commentary. The use of strong directive statements in teaching-type films is, in general, likely to promote greater learning than the commonly used impersonal type of commentary. Example, "do this" (imperative) or "you do this," etc. This finding is slanted toward military training objectives.

13. Phase or time relationship of audio to visual. The use of commentary which is in advance of the picture and alerts the viewer to forthcoming visual elements of importance may be desirable. The order of "lead" found most contributory to learning in a specific experiment amounted to a few seconds.

Of the measurements on the other factors in the list of thirteen, the following were found to be inconsistent or negative:

2. "How it works" film explanations. This variable showed results which were very inconsistent. Research is continuing.

3. Use of technical terms. The introduction of new names or technical terms was found to impede the learning-and-recall aspects of skills or performance-type instruction films where performance was the measure of learning.

5. Succinct treatment of subject. Condensed or succinct treatment of the subject was found to give exceedingly ineffective results. While educators have been aware of this danger, many film producers and technical advisers seem to consider compact productions to be satisfactory. Perhaps cost controls the matter. The term "succinct treatment" is used to refer to a production practice using a fast rate of development, minimal use of repetitions, and generally presenting only the *bare essentials* of the subject to be remembered. While this produces a complete minimum film presentation it was found to be 600% *less* effective than the better experimental teaching films.

11. Showing hands of the operator performing task. In the one case where a comparison was made between showing the hands of the operator and not showing them (moving objects by stop motion) results were inconclusive.

Factors Found Directly Related to the Effectiveness of Informational Films

The evidence indicates that films designed to impart *information* effectively parallel, to a large extent, the factors needed for skills instruction.

Slow rate of development and the use of built-in repetition are important contributors to effectiveness.

It has been found that film introductions and summaries may be designed to boost considerably the information retained by the viewer. A poor introductory sequence may mislead the viewers and impair learning.

People will retain more of the information shown when they are intentionally made aware of the amount that they have learned from the film. Such a "knowledge of results" may be made a part of the film. Commentary and flashback in support of a "how much do you remember" recapitulation may imply or lead to self-evaluation results. For teaching functions students learn far more when they are specifically kept informed of their progress.

Color films were found of help only when the color was of crucial importance in the imparting of a specific concept or "crucial cues" in the film.

It has been well demonstrated that information can be taught exclusively by means of films. Groups of viewers having no previous knowledge of the subject, who were supervised by unskilled instructors, learned as much from a series of films as equivalent groups who were trained by expert instructors. (Industry and military sponsors please note.)

Instructional films, if they are to be effective, must match the viewer's background experience and abilities in both an auditory and a visual sense. This indicates:

1. Several versions or treatments adapted to different audience levels;
2. the adoption of "production-stage" showings using sample audiences who are later subjected to recollection tests and other reactions to the film in preliminary form.

Factors Found of Interest in Attitude-Changing Films

So far, the research evidence suggests that film concepts influencing human behavior are most likely to be perceived and adopted if they do not conflict with prior opinions and belief systems of the viewers.

The established attitudes of viewers toward a film's main character and theme are matters of importance to the film's effectiveness in modifying attitudes. From a production point of view, the effectiveness of a film designed to change audience attitudes will depend on the selection of a main character who is suitable for "hero-worship" or "identification mechanisms" set up in the intended audience. Films which exclude the identification mechanism as a persuasive factor have not been proven capable of effectively altering human attitudes or behavior.

Functional Factors of Importance to Effective Learning From Films

A preliminary evaluation of the influence of functional factors on learning was measured by scoring Navy personnel after film instruction. About 2,000 men were used for these tests.

1. Viewing angle and screen distance. The optimum viewing area for a small "daylight" rear projection screen was established as about the same for both daylight and dark viewing conditions within an angle 60° wide. A negligible decrease in learning was found at viewing distances up to 16 screen widths from the screen (24 ft for an 18-in. screen). Of the men in the tests, 75% learned successfully in these positions and at these distances.

An area of reduced learning effectiveness extends around the optimum area to a maximum total angle of 100° for daylight viewing and 120° for viewing in the dark. The maximum viewing distance was 24 screen widths. Within this area 50% of the men learned successfully.

These results have important implications for film and television. The present standard of six times the screen width as the maximum satisfactory view-

ing distance might be revised for informational film theaters, etc.

2. Repetitive showings. The repetition of film showings added greatly to learning. Three showings resulted in significantly more men mastering an assembly task than did two showings.

3. Consecutive versus spaced film showings. The measurements indicated that consecutive presentation of several films was as effective in ensuring two-week retention of the film information as showings of the same films spaced over several days. The establishment of the efficiency of hour-long showings is of importance to military training applications.

Music in Informational Films

So far experimental evidence in this connection is not conclusive. The following discussion is suggested by the traditional psychological principles of learning, without the supporting evidence of experimental tests.

The researchers point out that the kind of music normally attached to informational films will certainly not operate to accentuate learning. Research has indicated that the mere presence of music may operate in many films to distract and divide attention, or to give the entertainment "set" for viewers. The following relationships suggest useful preliminary trends of thought to be confirmed by future experimentation.

Attitude and opinion molders. Music which is regarded highly by the audience might be used to set up favorable attitudes toward the audio-visual material in the film. The same device could operate in reverse and help form unfavorable attitudes.

Memory reinforcing. The strengthening of new learning by association of the familiar with the unfamiliar may be assisted by the use of familiar music as a framework to aid recall. The repetition of music with a given visual and its variations might be a desirable memory link.

Concept-forming aids. Music might be used as a clue suggesting association by inference with a new experience not previously related to familiar ones. In the same way, the function of music, used as a clue, might aid in pointing toward a problem's solution.

Emotional drives for learning. Music might provide an emotional tone or excitement to the learning experience. Correctly conceived informational films are *designed to leave unanswered questions* in the mind of the viewer toward the solution of which he must actively participate. Music might be used to provide a kind of reward, in that the viewer would feel pride in recognizing correctly the association intended by the music.

Music as a "pointer." Music might be used to direct attention to a particular occurrence in the visual stream or in the sound track. It might provide a source of direction for attention by overcoming previous distractions. Contrasting tone color might be used to sustain attention for long periods and prevent day dreaming.

Interpretation of Research Findings

Some Values of Film in Education, Instruction or Informational Roles

"Do films tend to be of significant value if used for education, training or information?"

1. Films have been found to be equivalent to a good instructor in teaching specific subjects. A longer retention of new information has been found in some cases than was achieved through other methods of instruction.

Discussion. The origin of this research was a postulation of a shortage of competent instructors in the event of a national emergency. The study was undertaken to determine to what extent instructional

films could carry the entire teaching burden using supervisors only.

As an example of the procedure by which this type of research was conducted the case is cited of three comparable groups of 9th grade high school students who were taught a four-unit course in general science over a period of a full semester. *The first group* was taught exclusively through a series of 44 films. *The second group* was taught through the medium of the same films. They also studied before and after each film from specially prepared short study guides. *The third group* was taught by competent teachers using a standard textbook and the customary classroom teaching techniques. No films were used.

The students were given objective tests immediately at the end of each unit of training. Three months after the end of the course a retention test covering all four units was given. They were also tested both before and after the experiment with a standardized test of general science knowledge.

Test Results. Analysis of the test results from the three groups revealed that the three methods were of almost equal effectiveness. The immediate recall tests gave slightly better scores in favor of the films plus study guides group over the classroom-taught group; the films only group was slightly inferior to both of these. The delayed recall tests indicated slightly better performance for the two film groups over the classroom-taught group. Of the two film methods the one using films plus study guides was slightly more effective.

Conclusions. The results of this study suggest that subject matter such as high school general science may be taught by films *alone* as effectively as by a good teacher using the usual repertoire of classroom techniques and demonstration materials. Films introduced and supplemented by brief study guides are better still. It is worth noting that the films selected for these teaching tests were produced without the benefit of the current research into the dynamics of learning through the medium of films. Nor did they make up a systematic series which thoroughly covered the subject matter. Correctly produced films should be able to provide a more than adequate solution for a shortage of competent instructors.

2. People can learn more in less time and retain longer the information derived from films made on these principles.

This has been demonstrated repeatedly when films have been tested against comparable reading materials or lecture presentations. The films required less instructional time. They imparted far more factual learning in the same time. Films in combination with other instructional materials are perhaps better than either alone. This holds for both the immediate and delayed measurements of the learning effects. Audiences have been found to remember more from a film after serveral weeks than after a few days or a few hours. These findings held true even when the films used in the tests did not conform completely to the principles disclosed in the current research.

3. Informational films have been designed to stimulate other learning activities.

When films incorporate established principles of learning they stimulate in viewer groups adult activities such as group discussions, teamwork and the like. Individual viewers have been induced to engage in voluntary reading. Motivation or desire to undertake the development of new skills was induced and followed by effective action.

4. Films have been found to facilitate thinking and to aid in problem solving.

Evaluation of the evidence of film research clearly indicates that the contribution of films as a communication medium is to give greater comprehension and understanding rather than to develop specific detailed recollection. Research studies have demonstrated that people taught by film were better able to apply their learning than people who had other forms of instruction.

5. In short, films can be specifically produced to influence viewer behavior in the long-term sense.

Thus through carefully produced films human beings can effectively acquire factual knowledge, the development of new skills, the formation of new attitudes, motivations and opinions. Films may be expected to effect other educational objectives such as appreciation, orientation, etc.

Evaluation and Summary of Experimental Research Have Suggested Principles Which Govern the Dynamics of Film Influence on Behavior

For convenience, each principle is stated and discussed and some practical implications for film production or utilization are suggested.

The overriding concept in the knowledge of the dynamics of film influence is that the meaning of a motion picture always differs among the people who see the film. What is perceived in a given film will differ with each viewer and will condition the meaning of the film to him.

In order to conform to the dynamics of learning, a film must contain familiar elements or backgrounds, and not too much that is completely new or unfamiliar such as interpretations that are not easily recognized. Yet there must be new information or there will be little learning. At the same time, understanding will be blocked should the information be too new or too difficult. To complicate matters, adult audiences demand or expect material which has the appearance of novelty. Otherwise they feel that their learning ability has been underestimated. Therefore a good training film must appear to challenge the viewer's learning ability. Thus it is essential to understand that while a motion picture does not vary objectively from one showing to another or from one group to another, there will be a variation in its meaning for different individuals. This will depend on the interaction between the psychological characteristics of the viewer, the social circumstances surrounding the audience and the content and treatment of the film. Any effective informational film will owe its validity to the matching of these variables.

First Principle—Films possess their greatest influence when their content has been designed to reinforce and extend the previous knowledge, attitudes or motivations of the viewer.

Discussion. A film will not substantially influence the behavior of a person unless that person can respond to the film in terms of what he already knows—or what he can do—or how he feels—or what he wants. The film can be designed to help change his attitudes and opinions, his knowledge and his skills, provided that it extends or reinforces those elements which he already possesses.

The effects of any motion picture depend on the reinforcing of the viewer's experiences which preceded, follow or are coincident with the actual film showing. Tests have shown that the influence of any one film is limited while the influence of several films is *cumulative* in the dynamics of learning.

Application. The sponsor's money will be wasted if the film is not carefully adapted to the viewer's knowledge-level, or if the film content is allowed to run counter to existing attitudes or motivations of the viewer.

From the sponsor's point of view, whether an influencing film is expected to extend and reinforce, or to reorganize and redirect the present behavior of the intended audience, a given film is ineffective unless it is *planned, produced, distributed* and *used* as one of a series of related and cumulative experiences operating in a common direction and all designed for the same specific viewers in the audience.

When it is the purpose of the sponsor to redirect behavior patterns and to reorient the motivations of an audience such as a group of Navy trainees, it may be necessary to reinforce the film with complementary impacts through other nonfilm avenues of instruction.

A second principle is that the behavior-influencing impact of film is usually specific and not general.

Discussion. The principle that films have a specific effect holds for all informational objectives. The cumulative effect of related films shown over a period of time and/or reinforced by other means of instruction may be general. Even here, however, this general influence is limited to the area of the instructional content of the films.

Application. From the production point of view, the sponsor has to be brought to the realization that instructional or informational films must be designed to achieve very specific objectives. A statement of film objectives in general terms is of little value to either a sponsoring or a producing agency.

Failure to define the film objectives specifically at the planning stage of production is a handicap which makes it highly improbable that the film will be effective in influencing behavior or otherwise creating conditions for viewer recollection. (Throughout this digest that aspect of viewer recollection which relates to the entertainment value of the film is excluded as being irrelevant to educational objectives.)

The third principle is that required film influence increases directly as the content of the film matches the specific audience response required by the sponsors.

Discussion. The subject of the film and the way that subject matter is treated is instrumental always and only to a specific end product of audience response. This means that the behavior pattern that the film is intended to produce must be directly related to the content and treatment of the film.

Application. It is necessary for the film sponsor to spell out the instructional or informational objectives in terms of the *specific behavior* the film is intended to influence. This means sponsors must indicate what or how the viewers are expected to know, think, feel or do as a result of seeing the films they buy.

When the film purpose is established in this specific way, production time, facilities and expense can be materially saved by the omission of content and treatment irrelevant to the specific behavior the film is intended to produce.

The effectiveness of a given film may be increased by audience participation relevant to the informational objectives.

The fourth principle is that variations in the prejudices or predispositions of the audience influence the reactions to a specific motion picture.

Discussion. Some elements of these variations depend upon audience literacy, abstract intelligence, formal education, age, sex, or previous experience in the subject. Differences in heredity and social experience mean equivalent differences in reaction to the film, and these differences seem to increase with maturity.

It has been found that intelligence and formal education are directly related. Viewers of above-average intelligence and education learn more from films than those with average or below-average education.

Below-average education viewers learn

very much *better* from films than from verbal instruction.

The retention of film content has been found to decline with age after a certain point.

Sex differences in response occur when the values or occupations shown in the film are sex-typed.

A film has bias but the bias of the audience also counts. The recollection tendency of the viewer depends on his acceptance, rejection or indifference to the bias of the film.

Tests show that the more an audience knows about a given subject the more it will learn from a film on that subject.

One interesting point which the research has brought to light concerns the influence of many films on the same viewer. The first principle showed that a series of related film experiences all operating in the same direction is cumulative. However, the fourth principle exemplifies the fact that the more films of any type which are seen the more the viewer tends to learn from any single film. People learn to learn from films.

Application. The research has disclosed that while the behavior-influencing impact of a film may be in the direction of the bias of the film the force of this impact will vary among the viewers depending upon their respective histories. To a surprising extent there will be instances of behavior influences the reverse of those intended by the film. An *effective* film will not have this result because its *production is planned and it is produced and used* according to an integrated psychology using the dynamics of learning.

Effective informational film planning, production and use depend on information as to the age, attitude, intelligence, education and social outlook of the specific audience for which the film is designed. These must be spelled out by the sponsoring agencies.

If informational films are designed for a general audience they should be sighted slightly below the average of intelligence and education rather than above it. This practice has been found to be the most effective treatment. Viewer learning was measured and it dropped rapidly when the "sighting" of the film was slightly above the audience educational level.

If a sponsor intends to influence audiences of widely different mental levels it has been found almost essential to have several versions of the film made for several IQ's.

The fifth principle is in two parts:

1. Both audio and visual elements of films are effective channels of communication. Neither channel is consistently better than the other. Each channel is uniquely capable of conveying certain types of information and the two should be properly integrated.

2. The overall influence of the motion picture is thought to be primarily in the picture and secondarily in the accompanying language. It is relatively unaffected by the slickness of production.

Discussion. The measurements indicated that the presentation of a film as a whole or the presentation of either the audio or the visual channel alone resulted in significant learning.

Both channels together were consistently better than either one alone. This "both" factor has been identified. It is established that some items are learned jointly from the audio and visual elements working together. Evidence also exists to show that items are often taught via both audio and visual channels in an overlapping sense, in which case the cumulative value of the "both" factor is reduced.

Color film has *not* been demonstrated as generally superior in information and instruction to black-and-white film.

Attention-gaining devices, either visual or auditory, have *not* been found to add significantly to learning in an otherwise correctly made informational film.

Optical effects and other film tricks have *not* been found to contribute sig-

nificantly to learning from informational films.

Too much or too little talking in words per minute of film has been found to detract from the teaching effectiveness of a film. The optimum word rate is about 100 words for each minute of film.

Application. No film should be planned that does not lend itself to fluent picture conception and specification.

With sound films equal care should be given to the verbal conception and specifications.

Since both channels together are more effective than either alone the objective is to achieve the best possible *integration* of the visual and audio elements of film. The "both" factor of this integration should be controlled. That is, single concepts should be imparted through the audio and visual channels working together.

The various attention-getting devices and other luxuries of entertainment films are found to be *not* significant in the dynamics of instruction by films and are seldom noticed by the audience.

The findings of these studies appear to be relevant to television.

The sixth principle is that the recollection of a film depends on the viewer's feeling that the action is significant and is in a familiar background.

Discussion. Not everything shown or said in a motion picture is seen or heard by the viewer. His response to film is selective not photographic. Scenes and sequences are best recalled when the pictorial background is familiar to the viewer and when the action has specific meaning to him. What counts is not the action but the importance of the action, not the close-up but the significance of the objects in the close-up, not the manner of performing the task but the meaning of the task to the viewer.

Application. The special forms of visual and audio film treatment such as cartoon, live photography, dramatic or straight treatments are not instructionally or informationally important in themselves.

Whatever form of treatment is used in the film, it is essential that important scenes and interpretations be *made to appear* important to the viewer.

Light humor helps, but slapstick hurts instruction and information.

The seventh principle is that an intense, efficient and predictable response occurs when the picture content has a personal relationship to the viewer.

Discussion. It has been found that the influence of the film on the attitude and factual learning of the viewer is related to the prestige attached by the viewer to the role of the principal character.

The position of the viewer, or zero camera angle, should be used instead of the 180° angle which is so frequently used in informational films. It has been found that the subjective approach is important to long-term recollection.

Showing the errors likely to be made when carrying out the task improves the instructional value of a training film.

Direct instructions or direct address to the viewer should be used. The third-person, passive voice has been found to retard learning.

Application. The content of an informational film is always better if it is treated in the way members of the audience would see the subject if they were dealing with it in real life.

The production treatment should be designed so that the viewer can see himself in the picture and identify himself with the principal characters.

The appropriateness of a film to an intended audience should determine its distribution. Its photographic excellence or its appeal to an expert should be secondary considerations.

The eighth principle is that the rate of development of a film's message must be slow rather than fast.

Discussion. Where recollection, learning or information rather than entertainment is involved, a slow, rather than a rapid rate of development is important. Rapid development of the presentation of a film subject reduces the amount of learning very materially.

Application. For maximum recollection it is necessary to gear the rate of development of the subject and the information of the film to the rate of learning of the audience. This presupposes that the audience level of intelligence is known.

The rate of learning of the audience is generally slower than the film producer thinks. It is a waste of the sponsor's money to try to cover too much too quickly in any one film.

The ninth principle is that instructional techniques built into the film or applied by an instructor substantially increase learning.

Discussion. The research conclusively shows that the following techniques add to the effectiveness of instructional films:

1. An orienting introduction and a relevant summary of the content of the film are of significant value.
2. An opening announcement of a check-up or quiz on the learning from the film measurably improves the recollection value.
3. Repeated film showings and/or repetition within the film itself, materially improve its recollection value.
4. Audience participation or practice during or following the film showing, "locks in" the teaching.
5. Presenting the viewer with a knowledge of the results of his learning is of great significance.

Application. For rapid mass teaching it is desirable to make films which undertake the total training. They should have instructional techniques and methods built right into them.

Auxiliary instructors can provide motivation, interest and leadership. These are necessary because motivation and morale carry over to the film learning even if the instructor is not present during the film showing.

These leaders or instructors should be trained in the dynamics of learning and its application to rapid teaching by film.

Conclusion

The unusual and commendable action of the Instructional Film Research Program in publishing interim reports on research in progress is planned to continue. These researchers point out that their main responsibility is *to do research* and, therefore, limits must be expected on the amount of report writing.

The most important implication of this work is that existing methods of film production and film utilization can be greatly improved by applying research methods. The conventional research into factors improving communication tools such as radio, motion pictures and television must be extended to become an exact knowledge of audience-influencing factors.

If the scope of communication is to meet the sponsor's requirements, if communication is to be extended behind the eyes and the ears to include effective influencing of viewer behavior, then the human engineering approach is essential for further advances in motion picture production and other branches of communication engineering. The communication industries have high stakes in this emerging field of research and application.

Present and Former Participants in the Instructional Film Research Program

Advisers and Consultants

Dean M. R. Trabue, School of Education (Chairman)
Dr. C. R. Carpenter, Director of Program (Secretary)
Dr. R. Adams Dutcher, Chairman, Research Council
Dean Ben Euwema, School of Liberal Arts
Dean George L. Haller, School of Chemistry and Physics
Dr. George F. Johnson, Professor of Agriculture Extension
E. L. Keller, Executive Assistant, Central Extension
Dr. Bruce V. Moore, Head, Dept. of Psychology
Dr. Eric A. Walker, Director, Navy Ordnance Laboratory
Dr. P. C. Weaver, Assistant Dean, Dept. of Education
I. C. Boerlin, Central Extension — Supervisor, Audio-Visual Aids
S. L. Land, Head, Dept. of Industrial Education
Hugh C. Pyle, Central Extension — Supervisor, Informal Instruction
Dr. Stephen Corey, Teachers College, Columbia University
Dr. Edgar Dale, Ohio State University
Dr. Charles Hoban, Jr., West Chester State Teachers College
Harold Kopel, Encyclopedia Britannica Films
Arthur A. Lumsdaine, Director, Yale Film Research Project
Dr. Mark A. May, Director, Institute of Human Relations (Yale)

Research Staff and Associates

Dr. C. R. Carpenter, Professor of Psychology, Director
Leslie P. Greenhill, Research Associate, Program Coordinator
Dr. Philip Ash, Associate Professor of Film Research
Dr. Nathan Jaspen, Associate Professor of Film Research
Edward McCoy, Research Assistant
Dr. Hugh M. Davison, Professor of Educational Research
Charles McIntyre, Research Assistant
Dr. Harold E. Nelson, Assistant Professor of Speech
Dr. Albert K. Kurtz, Professor of Psychology
Dr. Kendon R. Smith, Associate Professor of Psychology
Dr. Kinsley R. Smith, Professor of Psychology
Dr. Charles Hoban, Associate Professor of Education, The Catholic University of America
Dr. E. B. Van Ormer, Professor of Psychology
Dr. A. W. VanderMeer, Associate Professor of Education
Edward Abramson, Assistant Professor of Sociology
Dr. James Gemmell, Associate Professor of Economics
William Hittinger, Research Assistant
John Tyo, Research Assistant
Chester L. McTavish, Doctoral Candidate
Mrs. Marjorie Straube Mertons, Doctoral Candidate.
Joseph Murmin, Research Assistant
Miss Fanna E. Brown, Writer and Assistant in Drama
Sol M. Roshal, Research Assistant
John V. Zuckerman, Research Assistant
Joseph N. Grosslight, Assistant Professor of Psychology
Dr. William S. Vincent, Professor of Education
John Stein, Doctoral Candidate
Mrs. John Stein, Doctoral Candidate
John P. Kishler, Doctoral Candidate
D. Morgan New (Psychology), Doctoral Candidate
Dean S. Northrop (Education), Doctoral Candidate
Loran S. Twyford (Psychology), Doctoral Candidate
Miss Mary C. Welch (Education), Research Assistant

Engineering Research and Development

F. T. John, Engineer (Director)
John B. Cannon, Jr., Project Engineer
Reginald Eggleton, Project Engineer
Ray A. Bland, Draftsman
Charles Brouse, Construction Technician
Melhart D. Chelosky, Construction Technician

William E. Shaw, Construction Technician
Milton C. Stone, Construction Technician
Harris Zeitzew, Construction Technician

Motion Picture and Recording Staff

Frank S. Neusbaum, Administrative Head, Motion Picture Production
Delmer P. Duvall, Assistant Specialist, Motion Picture Production
Henry Miller, Associate Specialist, Motion Picture Production
Paul H. Seitzinger, Assistant Specialist, Motion Picture Production
Mrs. Marjorie Bloomfield, Secretary

Joint Military Services and Advisory Committee

Joseph Gaberman, Scientific Officer, Special Devices Center, O.N.R., Chairman
Fred E. Kelly, Signal Corps Photographic Center, Secretary
Dr. C. R. Carpenter, Director, Instructional Film Research Program
Dr. A. A. Lumsdaine, Human Resources Research Laboratories Air Force
Paul Murdock, Army Pictorial Service
L. J. Tate, Bureau of Personnel, Navy
Dr. William Timmons, Navy Photographic Center

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Audio-Visual Instruction Conference

Report by D. F. LYMAN

An invitation to attend the Winter Conference of the Department of Audio-Visual Instruction (DAVI) of the National Education Association was extended to Boyce Nemec, Executive Secretary of the Society of Motion Picture and Television Engineers, by Don White, Executive Vice-President of the National Audio-Visual Association, Inc. (NAVA), and J. J. McPherson, Executive Secretary of DAVI.

NAVA has been cooperating with DAVI and the American Association of School Administrators in preparing specifications for the design of classrooms and school buildings that will insure effective use of projected audio-visual material. In his invitation, Mr. White stated that two important points require immediate attention: methods of darkening classrooms; and provision in each classroom of the necessary facilities for projection. These include essentials such as conduits, switches and electrical outlets. This information is needed soon for the architects now designing the many school buildings that will be built in the next few years. Later, guidance will be needed on questions such as the optimum size and luminance of the screen, and the amount of illumination in the room during projection. Mr. White invited the SMPTE to cooperate in locating existing technical information and in helping with any research that may be needed. The Winter Conference was held by DAVI at the Hotel Kenmore in Boston on February 6–9, 1952, during which there were several meetings on this point.

Through arrangements made by F. T. Bowditch, Engineering Vice-President of SMPTE, the writer of this review went to the conference and attended the sessions of Action Planning Section 3, Buildings and Equipment.

A report submitted February 15, 1952, by D. F. Lyman, Eastman Kodak Company, Camera Works, 333 State St., Rochester 4, N. Y.

DAVI Organization

As brought out in the business meeting held on February 8, DAVI is an affiliate of the National Education Association, with Headquarters at 1201 16 St., N.W., Washington 6, D.C. A staff of six people handles the correspondence and other work of the organization. There are now over 1400 members, and the annual operating budget is $32,000 of which $6,000 is from membership dues. DAVI has 15 Action Planning Committees, of which 13 are now national in scope. Many are concerned with general educational problems related to the audio-visual field, but the following are of particular interest to the SMPTE: Section 3, Buildings and Equipment; Section 7, Instructional Materials; Section 8, Production of Audio-Visual Materials by Colleges and Universities; Section 10, Radio and Recordings in Education,

Section 11, Relationships Between Education and the Audio-Visual Industry; Section 12, Research; and Section 15, Television in Education.

As literary outlets, there are available to the organization *DAVI Proceedings* and the magazine *Educational Screen*. One committee is working on a *DAVI Yearbook on the Administration of Audio-Visual Programs* of which the first issue is due in the next year or two. As soon as the tentative specifications on Buildings and Equipment are finished by Section 3, they will be published in temporary form. Then in 1954, it is expected that the first *Yearbook on Buildings and Equipment for Audio-Visual Education* will be ready, with the results of the research now being instigated.

Operation of Conference

At this Winter Conference, there were over 350 registrants from 25 states and Puerto Rico. Their method of operating was different from that of the SMPTE in that prepared papers or lectures were restricted to two evening sessions and the final morning of the conference. There was a get-together luncheon on the first day, much like ours, but here a keynote address was given, after which the main group divided into Action Planning Sections which met in separate rooms for discussions and drafting of recommendations. In this conference most of the 15 groups, which varied in size from 8 or 9 people up to 50 to 60, met three times. There was also one business meeting in which the entire conference participated. One interesting variation took place on the final morning when a reporter summarized the work performed by the various committees at this conference. This was followed by a symposium on "Television's Challenge to Education," in which a chairman and seven speakers took part, after which the conference adjourned.

Buildings and Equipment Section

Section 3, Buildings and Equipment, is of particular interest to the SMPTE Committee on 16mm and 8mm Motion Pictures because of the work done in 1941 along the lines of projection in classrooms,[1] and the efforts, after the war, in which an uncompleted attempt was made to revise and expand the original report. Some of the research problems now confronting DAVI are the same problems that are listed on the SMPTE's agenda for research. The optimum screen luminances for various types of film and various levels of ambient illumination are included in this category.

A previous meeting of Section 3 had been held on November 17, 1951, in New York City.[2] Certain provisional drafts were available from that meeting, and several members had prepared recommendations on certain points for consideration by the group meeting in Boston.

General Architectural Planning

The notes that follow are not intended to give the exact content of the specifications, which are not yet in final form, but merely to indicate the general trend of the discussions. The first discussion dealt with the influence that the architects have on the design of school buildings and how they obtain their final plans. Some make a real effort to survey the needs of the community, while others work from drawings outlining certain requested features. Some school districts have definite ideas of what they want, and it is essential that in such cases the utmost cooperation be obtained from the architects. They stress, however, that they much prefer to work from stated requirements rather than merely to assemble architectural features that have been prescribed by someone else. In this way there is less restriction from a creative point of view.

Ideally, architects should have some training in education. One source of trouble in obtaining audio-visual facili-

ties has been that when costs of proposed buildings are high, features provided for audio-visual instruction are often the first to be scrapped.

In one city, 18 million dollars have been allotted for the rehabilitation of old buildings. There are many local committees working on their separate needs, from the standpoint of the uses to which the buildings are to be put. But fast action must be taken by this Section 3 if its recommendations are to be available in time for this large remodeling project. It was decided, therefore, that screens and other purchased accessories would be kept in the background for the present, and that the committee would concentrate on architectural recommendations for the buildings themselves.

Classrooms

Since there is general agreement that the classroom is the first and most important place to equip for audio-visual activities, certain details were laid down for such rooms. The items covered include the number of electrical outlets, their location, their current-carrying capacity, wall switches for the room lights, conduits for connections to the loudspeaker, acoustical properties of the room, for which standards outlined by the Acoustical Materials Association[3] were specified, ventilation, control of the illumination in the room so that 0.1 ft-c can be obtained during projection, storage of equipment, the size and type of screen, its location with the bottom edge at the eye level of the pupils in each particular room, the method of mounting the screen and dimensions of projection stands. A screen width of one-fifth the distance to the farthest row of seats was preferred to the usual one-sixth. In many ways this work parallels Adrian L. TerLouw's recommendations in the September 1945 *Architectural Record*.

Subjects for Research

The next considerations were of the questions that require research: the size and luminance of the screen with respect to the illumination in the room; the extent of the equipment needed; methods of raising the priority of audio-visual equipment and obtaining community support for it; methods of darkening the room; functions of building coordinators; and ways to persuade those who publish illustrations of "beautiful" classrooms to include audio-visual equipment and materials in their pictures, and to show the method of darkening the room.

A member from California showed a motion picture demonstrating an interlocking type of venetian blind that is engaged in channels. This screen, which has been used in some of their schools, lowers the illumination to about 0.5 ft-c under the outdoor lighting conditions encountered in California.

In this connection, there was some discussion of the possible advantages of windowless classrooms. Some members thought that if windows were omitted entirely, the benefits would be as follows: the pupils could neither see nor hear outside disturbing influences, such as street traffic; darkening of the room would not be a problem; the regular lighting for the classroom could be controlled more precisely; it would be easier to treat the room acoustically; and the acoustics would be constant, whether or not the room was darkened. Not much was said about the arguments against this idea.

In keeping with the precepts of those working in the audio-visual field, the committee made plans for the preparation and circulation of a film strip illustrating good practice in the design of classrooms, and possibly some of the things that should be avoided.

Auditoriums

Specifications for auditoriums were discussed next. Again the acoustical treatment was left to the specifications prepared by the Acoustical Materials Association. One member believed that

architectural conditions for auditoriums are so varied that the committee could not write effective specifications. For example, some architects are now discouraging the construction of projection booths because of the complications and expense involved. It was decided that there should be no reference to a booth, but that the switches, outlets, conduits and other facilities should be specified for a "projection station." Thus the projector could be located in a booth or in some other spot where it would interfere as little as possible with the functioning of the auditorium. Here the screen size was made one-fifth the distance to the rear row of seats, but not greater than 9 ft × 12 ft. Plans were made for connecting the audio-visual equipment to the large public-address system in the auditorium, whenever possible. It was agreed that the auditorium should have no windows, and some believed that the illumination should be even less than the 0.1 ft-c specified for the classroom.

Preview Rooms

It was decided that a statement should be included in the recommendations that audio-visual activities belong in the classroom or in the auditorium, and that no attempt should be made to substitute a central room reserved for audio-visual instruction only. Some members, however, stressed the need for a room where the teachers can preview the material they are going to use in the classroom. Then there must be space for storing equipment and editing films. In some schools there should be office space for the director of audio-visual aids. In many cases these facilities can be provided in one room, and this room should be centrally located and near the library.

Special Reports

Submitted to the committee for guidance at this meeting, a *Preliminary Report of a Study of the Problems of Light Control in the Classrooms of Southern Calilifornia*, was of considerable interest. This was prepared by the Research Committee of the Audio-Visual Education Association of California, Southern Section. It is not complete, but it does cover 567 schools and 8591 classroom units. Only about one-third of the classroom units have satisfactory control of the light for projection. The same ratio applies to 886 classrooms under construction, but of 589 classrooms in the planning stage, only 12% are being equipped for darkening. Of 191 classrooms being remodeled, or in the planning stage for remodeling, only 20% are being so equipped.

This is a serious situation because it looks like retrogression instead of progress. The report points out that large expenditures have been made for audio-visual materials and equipment, yet "Audio-visual directors have been faced with the dilemma of spending money and energy developing audio-visual resources only to have difficulty at the point of application, the classroom, where, in too many cases, no light control exists and children cannot see the fine films and other materials that are available to help them learn."

Some architects are advocating the use of small, bright screens in fairly well-lighted rooms. Illuminations of 10, 15, 50, or even more, foot-candles are mentioned. This information applies particularly to slides. Whether or not the picture is still effective with the low contrast obtained in this way is a factor that should be considered.

Need for Liason

The Society of Motion Picture and Television Engineers can be of assistance to the DAVI committee because of the fund of information in its carefully prepared *Journal*. Some of this is now being furnished directly to Action Planning Section 3 of DAVI. Certain SMPTE committees may find it desirable to cooperate directly with DAVI committees.

The personnel of the DAVI organization have much more direct knowledge of what is transpiring in the educational field than most of our members have, and they know much better what the real needs are. When the DAVI committee starts to write specifications or recommendations for equipment, it will need a great deal of help because of the complexity of the problems involved.

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Television Studio Lighting

Committee Report by RICHARD BLOUNT

THE TELEVISION STUDIO LIGHTING COMMITTEE of the SMPTE met in New York City on April 16, 1952, to discuss means of measuring studio lighting. As originally planned, the meeting was attended by numerous lighting directors from the various networks who provided the practical approach to this problem. From the discussion, it became apparent that incident light is measured because simple meters are available, but that brightness would be measured if a meter of similar simplicity and size were available. Since such a device will probably be somewhat more difficult to obtain, the Committee decided to establish desirable characteristics of both types of meters with the thought that an incident meter could be made without any great delay. This would give the studio personnel a standard measuring device which could be used until a convenient brightness meter can be produced.

The following listing of specifications was tentatively agreed to at the meeting, and these are to be given wide publicity among meter manufacturers and users for further suggestions. These proposed specifications are being published here to encourage comment from any interested reader of this report.

Specification for an Incident Light Meter

1. The spectral sensitivity shall conform closely to that of the 5820 image orthicon camera tube.

2. The coverage angle shall closely approach a cosine distribution, i.e., the response shall be maximum perpendicular to the plane of the photocell and shall be 70% of the maximum at ±45° from the perpendicular.

3. The meter shall have a single scale and shall respond from 0 to 300 ft-c. The scale shall be logarithmic with 0 to 30 ft-c covering approximately 25% of full scale.

4. The size, and weight and shape shall be such as to be conveniently carried in a suit coat pocket. Rounded edges are desirable since the meter will be hand held in use. A maximum thickness of one inch is desirable.

5. An adjustable-length neck cord is required. The maximum length should allow the meter to rest in a trousers pocket.

6. The meter should withstand reasonably rough handling similar to that experienced by photoelectric exposure meters. A storage case may be provided at the manufacturer's option.

Preliminary Specifications for a Portable Brightness Meter

1. The instrument shall incorporate a photoelectric device for light measurements and shall be dependent upon the human eye for aiming only.

2. The spectral response shall be similar to that of the 5820 image orthicon camera tube.

A report submitted on April 23, 1952, by the Committee's Chairman, Richard Blount, General Electric Co., Nela Park, Cleveland 12, Ohio.

3. The angle of coverage shall be $1^{\circ}{}^{+1^{\circ}}_{-0^{\circ}}$.

4. The instrument shall measure brightness from 70 ft-L max down to 1 ft-L, with 0.1 ft-L as a very desirable minimum. This range may be covered by a number of steps—perhaps in multiples of 10. Switching between steps should be accomplished internally. No separate, external filters or other devices shall be used.

5. A sight or viewfinder which provides an upright image shall be incorporated. It shall enable the operator to quickly and positively identify the area to be measured. Parallax shall be kept to a minimum.

6. The meter shall be designed so that the operator can make a single measurement in less than five seconds, but will allow him to read the actual value at his leisure.

7. The meter shall not require external power and shall be built as a single unit.

8. If battery-operated, it shall be able to operate continuously for at least 10 hours on a single set of batteries.

9. The calibration shall be stable throughout the battery life. A simple external calibration device shall be made available.

10. The meter should not exceed 400 cu in. and the weight shall be no greater than 5 lb.

The Committee appreciates that the brightness meter specifications may be difficult to meet, but in the apparent absence of any meter that meets the needs of television stations, it was decided to state the precise requirements and compromise later if necessary.

Revision of Screen Brightness Standard

THE PROPOSAL of the Screen Brightness Committee to revise Z22.39-1944, Screen Brightness for 35Mm Motion Pictures, is limited solely to the addition of a phrase excluding outdoor theaters.

A careful survey did not indicate a need for changing the brightness level recommended for indoor theaters and the proposed change simply recognizes the problem of outdoor theaters. These theaters, with their large screens, were not originally considered in arriving at the standard for screen brightness, and a large portion of these are unable to meet the standard with presently available equipment; hence the screen brightness standard has been revised to pertain solely to indoor theaters.

Due to the fact that both indoor and outdoor theaters use the same release prints, the Screen Brightness Committee voted to add a note urging the outdoor theaters to use this standard as a goal. The Standards Committee supported this position and authorized preliminary publication for a 90-day period of trial and criticism.

Please send comments to Henry Kogel, Staff Engineer, at Society Headquarters, before August 15, 1952. If no comments are received during the three-month trial period, this revised standard will then be submitted to ASA Sectional Committee PH22 without further vote within the SMPTE and with the recommendation that it be processed as an American Standard.

Proposed American Standard

Screen Brightness for 35mm Motion Pictures

PH22.39

Revision of Z22.39 – 1944

Screen Brightness

The brightness at the center of a screen for viewing 35mm motion pictures in indoor theaters shall be 10^{+4}_{-1} foot-Lambert when the projector is running with no film in the gate.

Note: Outdoor theaters have been excluded from the above standard because of their inability to meet it. It is recommended that outdoor theaters approach the indoor standards as closely as possible in view of the fact that the same release prints are generally used for both types of theaters.

NOT APPROVED

Engineering Activities

71st Convention The Engineering Committee meetings at the 71st Convention were in the main well attended and demonstrated a high degree of member participation and interest. The highlights of the meetings are:

Film Dimensions The further decrease in the shrinkage characteristics of 16mm film creates a twofold problem: (1) the width must be decreased to preclude film stickage in the gate; and (2) a decrease in the stated width dimension in the standard might erroneously lead equipment manufacturers to decrease the gate dimension and thereby start a disastrous merry-go-round.

The proposed solution was that the existing standard be revised by placing an asterisk beside the width dimension and indicating below that for low-shrink film the standard is 0.628 ± 0.001. Low-shrink film would then be defined in the Appendix. A letter ballot on this proposal will be sent shortly to the full committee.

Film-Projection Practice The committee first outlined plans for a major increase in activity and then reviewed a previous recommendation that American Standard Z22.58, Projector Aperture Dimensions, was unsuitable for international standardization. It is now felt that although certain features of the standard do require revision, the basic dimensions are valid and valuable both here and abroad and the previous recommendation was therefore reversed.

Laboratory Practice The three active projects were reviewed and a fourth one proposed:

1. The Proposed American Standard Enlargement Ratio for 16mm to 35mm Optical Printing, published in the January *Journal*, is now well on its way toward standardization.

2. Screen Brightness for Laboratory Review Rooms, presently out to letter ballot, is meeting with difficulty primarily because of the conflicting needs of three classes of 16mm print consumers: amateur, television and Navy. This is now to be considered by the Screen Brightness Committee, after which this committee will attempt to draft a compromise proposal.

3. Printer Light Change Cueing of 16mm Negatives, a proposal to eliminate negative notching, has just been sent to the committee. Preliminary comments at the meeting indicated that redrafting may be required.

4. A new project to produce a glossary of chemical terms used in motion picture laboratories was initiated.

High-Speed Photography In addition to the primary discussion on preparations and responsibilities for the symposium at the Fall Convention in Washington, the committee discussed the need for a glossary and agreed upon the initial steps to achieve one.

Screen Brightness The various subcommittees reported on their progress to date and mention was made of the formation of a new subcommittee on illumination practices to make recommendations on uniformity of illumination across the screen. The ICI recommendations on screen brightness were discussed and it was noted that the American Standard falls within the recommended range:

ICI = 7.3–14.6 ft-L
American Standard = 9–14 ft-L

Plans were made to continue the screen brightness survey of outdoor theaters as soon as weather permits.

16mm and 8mm An extensive agenda was considered and a continued high level of activity projected. As a result, the full committee will soon be voting on revisions of six standards in an effort to make them consistent as to emulsion position, edge guiding and titles (Z22.9, .10, .15, .16, .21, .22). A letter ballot is also to be taken on a compromise proposal on PH22.75, "A" and "B" Windings of 16mm Raw Stock which may resolve the existing deadlock on this thorny issue. Reels for a 15-min show (600-ft size) as well as reels over 2000 ft were discussed and assignments given for gathering additional required information.

Sound Of the several items considered, the magnetic sound track proposals were, of course, paramount. These were published in the July 1951 *Journal* for trial and criticism and it was up to the committee to pass on the comments received. After a full and rounded discussion, the committee approved the proposals as published, with minor modifications which in the main are editorial in nature, and officially submitted them to the Standards Committee for further processing as American Standards.

Consideration was briefly given to other magnetic sound track proposals and also to magnetic test films. The nature of the discussion revealed the need for a meeting of the Magnetic Recording Subcommittee which was scheduled for and held the following day. The Subcommittee reached no decisions but proceeded efficiently to outline a major program of work on test film specifications (azimuth and multifrequency) and additional sound track standards.

ISO Delegation A very workmanlike job was done to prepare the group for its role at the forthcoming meeting of ISO TC/36 in New York on June 9 and 10. The delegation discussed point by point the position it would take on the various Agenda items. A copy of the Agenda for the international meeting and the U.S. position is available upon request.—*Henry Kogel*, Staff Engineer.

University Film Producers Association

The University Film Producers Association held its first meeting in the summer of 1947 at the University of Iowa, Iowa City, Iowa. The organization came into being as a result of the evidenced need for university film makers to meet and discuss their mutual problems. The initial session was a one week's conference and workshop. This pattern was so successful that the group still follows it.

At the time of the first meeting, many problems confronted the university film producers, such as personnel, music rights, exchange, distribution, technical practice and laboratory service. Many universities had the same problems. Some had solutions, some did not. It was evident that a clearinghouse was needed for the exchange of information and ideas.

The first meeting included representatives from nine educational institutions and two commercial organizations. Today there are approximately 60 members from educational institutions, as well as representatives from commercial film companies, laboratories, film distributors, and equipment manufacturers.

The purpose of the University Film Producers Association has been very clear since the inception of the organization. "It shall be the purpose of the UFPA to further and develop the potentialities of the photographic and recording arts in improving instruction and communication." Individuals, organizations and educational institutions qualified for membership are encouraged and invited to join the University Film Producers Association. There are at present four classifications of membership: active, associate, institutional and sustaining.

In its half-dozen years of existence the UFPA has grown in accordance with its original plans. It is today an incorporated, nonprofit organization whose members include teachers, professors, film makers, film technicians, film companies, film laboratories, film distributors, equipment manufacturers and dealers, and university motion picture students.

Annually, during the month of August, the Association meets in a city chosen by the members. August of 1952 will find the organization guests of Syracuse University, Syracuse, N.Y. The week-long conference includes a variety of program subjects, such as technical problems of film production, research, film curriculums, distribution, film screenings and films for television. Equipment manufacturers and distributors display and demonstrate new equipment at the meetings. The lectures, demonstrations, round tables, panel discussions and original papers offer the membership introduction to new areas and developments in the film field. A highlight of the annual session is the presentation of awards for outstanding films produced by the university film makers.

Officers of the organization are:

John R. Winnie, University of Iowa, *President*
Wilbur Blume, University of Southern California, *Vice-President*
Roland J. Faust, Indiana University, *Secretary-Treasurer*

Communication regarding membership should be addressed to the Secretary. Information concerning Journal subscription or manuscript submission should be sent to the Editor, Lu Snyder, Audio-Visual Center, Syracuse University, Syracuse, N.Y.—*John R. Winnie.*

Obituary

Louis Gerard Pacent, an early researcher for sound motion pictures, died in April at the age of 58.

Mr. Pacent began experimenting with wireless transmission when he was a youth and he had his own amateur station when he was 16. In 1913 he was a communicator in the Naval Militia and in 1917 he served aboard the U.S.S. Gloucester. Also during World War I he worked on the development of military communications equipment.

After that war he organized the Pacent Electric Company, Inc., which was active in the design and production of electric and radio facilities for General Electric, Westinghouse, Western Electric, RCA and the Government. Before World War I he was influential in encouraging and instructing amateurs and in 1921 the first short-wave transatlantic message was transmitted to Scotland from Greenwich, Conn., on 200 meters which had been Mr. Pacent's suggestion.

Mr. Pacent was active in research for sound motion pictures in the 1920's. He is reported to have designed the first all power-operated motion picture sound equipment while a consultant for Warner Brothers Pictures, the equipment having been installed in 1928.

At the time of his death he was president of the Pacent Engineering Corp., a firm which he had founded 20 years ago. The corporation developed portable sound reproducers, inter-office communicating equipment, high-fidelity radio and public address systems.

In 1946 Mr. Pacent was given a Certificate of Appreciation by the War Department in recognition of his firm's valuable assistance to the Signal Corps during World War II.

He was a native of New York and was graduated in 1916 from Pratt Institute of Technology with the degree of Industrial Electrical Engineer. He was the author of many papers and books on communications engineering. He was a Fellow of this Society and also of the Institute of Radio Engineers, and a member of the American Institute of Electrical Engineers. In 1951, he received the Marconi Memorial Medal of Achievement from the Veteran Wireless Operators Association.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1950 MEMBERSHIP DIRECTORY.

Honorary (**H**) Fellow (**F**) Active (**M**) Associate (**A**) Student (**S**)

Aicher, John W., SRT-TV Studios. **Mail:** 400 W. 56 St., New York 19, N.Y. (**S**)

Bailey, G. C., Export Sales, Eastman Kodak Co., Rochester, N.Y. (**A**)

Bailey, James H., Projectionist, Warner Brothers Studio. **Mail:** 813 N. Rose St., Burbank, Calif. (**A**)

Behrmann, Louis L., Photographic Technologist, U.S. Naval Research Laboratory. **Mail:** 12240 Viers Mill Rd., Silver Spring, Md. (**A**)

Belinkoff, Irving R., Junior Engineer, Federal Manufacturing & Engineering Corp. **Mail:** 449 Beach 67 St., Arverne, L.I., N.Y. (**A**)

Bernier, Maj. Robert V., U.S. Air Forces. **Mail:** 4505 Arcadia Blvd., Dayton 10, Ohio. (**M**)

Bessor, John O., Jr., Motion Picture Cameraman, Byron, Inc. **Mail:** 1537 Roosevelt Ave., Falls Church, Va. (**A**)

Bordelay, Jack F., Director, Cameraman, Syracuse University. **Mail:** 108 Comstock Ave., Syracuse 10, N.Y. (**A**)

Braunstein, Simeon, Director, Photo Section, Engineering Research Div., New York University. **Mail:** 2666 Valentine Ave., New York 58, N.Y. (**M**)

Buckner, W. C., Vice-President and Chief Engineer, NECO, Inc. **Mail:** 12132 Herbert St., Culver City, Calif. (**M**)

Carrington, H. K., Motion Picture Producer, Nationwide Pictures, Melba Theatre Bldg., Dallas, Tex. (**A**)

Cass, Lewis S., Recording Technician, Paramount Pictures. **Mail:** 240 W. 98 St., New York, N.Y. (**A**)

Cooper, James E., Motion Picture Film Editor and Projectionist, The Calvin Co. **Mail:** 3208 Highland Ave., Kansas City, Mo. (**A**)

Creamer, C. C., Partner, Theatre Equipment Business. **Mail:** 75 Glenwood Ave., Minneapolis, Minn. (**A**)

Dellins, Bert A., Motion Picture and Sound Salesman, Fotoshop, Inc. **Mail:** 112-41 — 72 Rd., Forest Hills 75, L.I., N.Y. (**A**)

Diament, Clifton L., Motion Picture Laboratory Technician, Byron, Inc. **Mail:** 1017 Dashill Rd., Falls Church, Va. (**A**)

Dickerson, Malon, Chemical Physicist, Southwest Research Institute. **Mail:** 8500 Culebra Rd., San Antonio 6, Tex. (**A**)

Dratch, Nicholas, Quality Control Engineer, Bolsey Corp. of America. **Mail:** 1569 Metropolitan Ave., Bronx 62, N.Y. (**A**)

Faber, John, Technical Representative, Eastman Kodak Co. **Mail:** 5 Edgewater Dr., Denville, N.J. (**M**)

Faust, A. Donovan, Assistant General Manager, WDTV (Allen B. DuMont Laboratories, Inc.). **Mail:** 121 Abbeyville Rd., Pittsburgh 28, Pa. (**A**)

Fielding, Raymond, University of California at Los Angeles. **Mail:** 1333½ Federal Ave., Los Angeles 25, Calif. (**S**)

Freedman, Myron L., General Manager, Crescent Film Laboratories, Inc. **Mail:** 7510 N. Ashland Ave., Chicago 26, Ill. (**M**)

Garcia, Orlando M., Custom House Broker. **Mail:** Habana #412 (Altos), Entre Obispo y Obrapia, La Habana, Cuba. (**A**)

Geis, Donald C., Sound Engineer, Hearst Metrotone News, Inc. **Mail:** 5939 Forest Glen Ave., Chicago 30, Ill. (**A**)

Geller, Gilbert, Cameraman, Films for Industry. **Mail:** 160-37 Highland Ave., Jamaica, L.I., N.Y. (**A**)

Gimborn, Charles J., Jr., Chief Motion Picture Photographer, WCAU-TV. **Mail:** 412 W. Delphine St., Philadelphia 20, Pa. (**A**)

Giovanelli, Frank, Cameraman (Animation), Consolidated Film Industries, Inc. **Mail:** 2716 Marion Ave., Bronx 58, N.Y. (**M**)

Giovanelli, Frank Jr., Consolidated Film Industries, Inc. **Mail:** 2716 Marion Ave., Bronx 58, N.Y. (**A**)

Glandbard, Max, Producer, Filmwright Productions, Inc. **Mail:** 195 Mohawk Dr., River Edge, N.J. (**A**)

Goldsmith, Charles B., Sound Technician, Radio Corp. of America. **Mail:** 307 S. Kenter Ave., West Los Angeles, Calif. (**A**)

Goldstein, Raphael L., Projectionist, Television Film Editor, South City Drive In, WFIL-TV. **Mail:** 1812 S. Fifth St., Philadelphia, Pa. (**A**)

Griffiths, Peter H., Electronic Engineer. **Mail:** 28 Eccleston Rd., South Shore, Blackpool, England. (**A**)

Grove-Palmer, Clifford O. J., Research Engineer, British Admiralty, Royal Naval Scientific Service. **Mail:** 59 Kings Rd., Rosyth, Dunfermline, Fife, Scotland. (**M**)

Harvard, Emile A., Motion Picture Producer, Cameraman, Harvard Productions. **Mail:** Box 1597, Tel Aviv, Israel. (**A**)

Henion, William C., Project Engineer, USAF Projection Equipment, Box 8015, Area B, Photo Reconnaissance Laboratory, WCE, WADC, WPAFB, Dayton, Ohio. (**A**)

Henning, Clarence G., Photographic Technician, David White Co., 315 W. Court St., Milwaukee 12, Wis. (**M**)

Holloway, F. P., Carbon Development Engineer, National Carbon Co., Div. of U.C. & C. Corp., Fostoria, Ohio. (**M**)

Hooper, Joseph K., Laboratory Manager, Byron, Inc. **Mail:** 1608 Tyler Ave., Falls Church, Va. (**A**)

House, Robert A., Film Recording Group, Radio Corp. of America, RCA Victor Div. **Mail:** 3309 Gwinett Walk, Crescent Park Apts., Camden, N.J. (**A**)

Johnson, Virgil L., Order Dept., Motion Picture Laboratory, Byron, Inc. **Mail:** 2816 Buena Vista Ter., S.E., Washington 20, D.C. (**A**)

Kalian, Peter, Chief Photographer, Atomic Energy Project, University of California. Box 4164, West Los Angeles 24, Calif. (**A**)

Keating, Clifford M., Technologist (Photographic Chemistry), U.S. Naval Photographic Center. **Mail:** 147 Ivanhoe St., S.W., Washington 20, D.C. (**A**)

Kern, Albert W., Assistant Cameraman, Free-lance. **Mail:** 49 County Center Rd., White Plains, N.Y. (**A**)

Kimura, T., Chief, Liaison Dept., Daiei Motion Picture Co. **Mail:** #2, 3-Chome, Kyobashi, Chuo-ku, Tokyo, Japan. (**M**)

Klages, William M., Television Engineer, National Broadcasting Co. **Mail:** 451 W. Fulton St., Long Beach, N.Y. (**A**)

Koster, William D., Laboratory Technician, Byron, Inc. **Mail:** 10422 Haywood Dr., Silver Spring, Md. (**A**)

Layne, Joseph L., Mechanical Engineer, Signal Corps Engineering Laboratories. **Mail:** 116 Fifth Ave., Neptune, N.J. (**A**)

Leighton, Thomas C., Optical Engineer, John H. Ransom Physics Laboratories. **Mail:** 3108½ W. 67 St., Los Angeles 43, Calif. (**A**)

Lewis, Keith B., Manager, Washington Office, Eastman Kodak Co., 444 Shoreham Bldg., Washington 5, D.C. (**M**)

Lewis, Robin R., Motion Picture Laboratory Supervisor, U.S. Army Signal Corps. **Mail:** 260–44 Langston Ave., Glen Oaks, L.I., N.Y. (**A**)

Mabrey, Layton, Motion Picture Director, Extension Div., University of Oklahoma. **Mail:** Box 615, N.C., University of Oklahoma, Norman, Okla. (**A**)

Mamas, Harry, Cameraman, Telecraft Film Productions. **Mail:** 17 Adams St., Medfield, Mass. (**A**)

Marchiel, Stanley, Sensitometric Sound Control, Paramount Pictures, Inc. **Mail:** 81 Oakland St., Brooklyn 22, N.Y. (**M**)

Marks, Jesse, Contract Negotiator and Administrator, U.S. Navy Motion Picture Exchange, Bldg. 311, N.Y. Naval Shipyard, Brooklyn 1, N. Y. (**M**)

Martens-Hughes, Margot, Visual Aids Specialist, IIA, U.S. Dept. of State, 1778 Pennsylvania Ave., Washington, D.C. (**A**)

Merriken, George T., Production Manager, Byron, Inc. **Mail:** 112 Lynmoor Dr., Silver Spring, Md. (**A**)

Miller, Robert W., Composer and Musical Director. **Mail:** 4097 Valley Meadow Rd., Encino, Calif. (**A**)

Moe, Sigurd M., Sound Recording Technician, U.S. Navy. **Mail:** Combat Camera Groups Pacific, Com Nav FE, FPO San Francisco, Calif. (**A**)

Mundell, J., Newsreel Cameraman, WBAP-TV. **Mail:** 2013 Ruea, Grand Prairie, Tex. (**M**)

Nordman, 2d Lt. Robert G., Photo Eng. Section, U.S. Air Force, Edwards Air Force Base, Edwards, Calif. (**A**)

Oller, Arthur H., Jr., Motion Picture Laboratory Technician (Timer), George W. Colburn Laboratory. **Mail:** 4416 Florence Ave., Downer's Grove, Ill. (**A**)

Pabst, Glenn C., Photographer, Bell Aircraft Corp. **Mail:** 17 Raymond Pl., Hamburg, N.Y. (**A**)

Parker, B. E., Engineer, Gates Radio Co. **Mail:** 720 Kentucky St., Quincy, Ill. (**M**)

Peltz, Leo G., Radar Technician, North American Aviation, Inc. **Mail:** 500 Seventh St., Manhattan Beach, Calif. (**A**)

Pierry, Michael J., Jr., Quality Control, Precision Film Laboratory. **Mail:** 285 James St., Teaneck, N.J. (**A**)

Plakun, Bernard D., Technical Writer, General Precision Laboratory, Inc. **Mail:** 15 Maywood Ave., Port Chester, N.Y. (**A**)

Portalupi, Piero, Director of Photography, Lux Film. **Mail:** Viale Bruno Buozzi, 83 int F, Rome, Italy. (**M**)

Pratt, Harry E., Sales Representative, W. J. German, Inc., 6700 Santa Monica Blvd., Hollywood 38, Calif. (**M**)

Rayhack, Michael, Free-lance Motion Picture Cameraman, Local 644, IATSE. **Mail:** 10 Overlook Ave., Box 284, Great Notch, N.J. (**A**)

Rosso, Lewis T., Production Manager, Republic Productions, Inc. **Mail:** 4703 Mary Ellen Ave., Sherman Oaks, Calif. (**M**)

Ruellan, Gilbert, Director, Etablissements Andre Debrie. **Mail:** 16 Rue Piccini, Paris 16°, France. (**M**)

Russey, Elwood M., Vice-President, Byron, Inc. **Mail:** Box 45, R.F.D. #1, Vienna, Va. (**M**)

Scherer, Marc, SRT-TV Studios. **Mail:** 121 Parkside Ave., Brooklyn 26, N.Y. (**S**)

Schnebly, John C., Motion Picture Laboratory Technician, Byron, Inc. **Mail:** 219 Winchester Way, Falls Church, Va. (**A**)

Silverman, Bert, Film Editor, CBS-TV. **Mail:** 999 Aldus St., New York 59, N.Y. (**A**)

Skinner, John M., Laboratory Technician (Printing), Byron, Inc. **Mail:** 127 Rolph Dr., Forest Heights, Md. (**A**)

Small, Elliot H., Photographer, Shell Oil Co. **Mail:** 55 Auburn St., West Medford 55, Mass. (**M**)

Smith, Newland F., Television Engineer, WOR-TV, General Teleradio, Inc. **Mail:** Spruce St., Riverside, Conn. (**M**)

Smith, Robert E., Television Engineer, National Broadcasting Co. **Mail:** 1001 Riverside Dr., Burbank, Calif. (**A**)

Smith, Thomas W. B., Regional Geologist, Gulf Oil Corp. **Mail:** Box 1166, Pittsburgh 30, Pa. (**A**)

Spafford, Ronald W., Assistant to General Sales Manager, Industrial Products, National Carbon, Ltd. **Mail:** 345 Kingsdale Blvd., Willowdale, Ont., Canada. (**A**)

Speed, William C., President, Audio Devices, Inc., 444 Madison Ave., New York 22, N.Y. (**M**)

Stehney, Michael C., Photographer, Director, Sarra, Inc. **Mail:** 18411 Dundee, Homewood, Ill. (**M**)

Stone, James, Engineer, Consolidated Film Industries, Inc. **Mail:** 426 Ivy La., Englewood, N.J. (**M**)

Taris, Charles M., Member, Technical Staff, Bell Telephone Laboratories, Inc. **Mail:** 11 Adams Ave., Cranford, N.J. (**A**)

Taylor, Barney L., Chief Dental Technician, U.S. Navy. **Mail:** 534 Eleventh St., NHA2, Honolulu 18, Hawaii. (**A**)

Teasley, Ernest, Secretary-Treasurer, EDL Co. **Mail:** Miller Station, Gary 5, Ind. (**A**)

Thorn, Thomas C., Laboratory Manager, Pathescope, Ltd. **Mail:** 29 Florida Rd., Thornton Heath, Croydon, Surrey, London, England. (**M**)

Todaro, Fred G., Design and Engineering, Negative and Positive Processing Equipment, Color Service Co. **Mail:** 320 Albemarle Rd., Brooklyn, N.Y. (**M**)

Tydings, Kenneth S., Photographic Author, Podiatrist. **Mail:** 110 E. Chester St., Long Beach, N.Y. (**A**)

Vance, Robert G., Cameraman, Byron, Inc. **Mail:** Route 4, Box 325, Alexandria, Va. (**A**)

Vanoni, Vito A., Professor, California Institute of Technology, Hydro Laboratory, Pasadena 4, Calif. (**A**)

Vary, Willard E., Head, Physical Tests Div., U.S. Naval Photographic Center. **Mail:** 2107 Ft. Davis St., S.E., Washington 20, D.C. (**M**)

Webb, Harry, University of Minnesota. **Mail:** 813 University Ave., S.E., Minneapolis, Minn. (**S**)

Weiss, J. Paul, Research Physicist, Photo Products Dept., E. I. du Pont de Nemours & Co., Inc. **Mail:** 908 New England Dr., Westfield, N.J. (**M**)

Young, H. A., Electrical Design Engineer, RCA Victor Div. **Mail:** 702 N. Naomi, Burbank, Calif. (**A**)

Zambuto, Mauro, Technical Director, Motion Picture Studio, Scalera Films. **Mail:** Via Cavour 114, Rome, Italy. (**M**)

Zan, Aung Phaw, University of Southern California. **Mail:** 1072½ W. 31 St., Los Angeles 7, Calif. (**S**)

CHANGES IN GRADE

Cruse, Andrew W., (**A**) to (**M**)

DuVall, John W., (**A**) to (**M**)

King, Roy D., (**A**) to (**M**)

Paul, Morrison B., (**A**) to (**M**)

Petrasek, A. G., (**A**) to (**M**)

Potter, Johnson, (**A**) to (**M**)

Valentine, Fred, (**S**) to (**A**)

Wadlow, Huston E., (**A**) to (**M**)

Wendt, Paul R., (**A**) to (**M**)

Willey, Lyle E., (**A**) to (**M**)

Book Reviews

IES Lighting Handbook (Second Edition)

Published (1952) by The Illuminating Engineering Society, 1860 Broadway, New York 23. i-xiii + 740 pp. + 37 pp. appendix + 24 pp. index + 172 pp. advt. 482 illus. + numerous tables. 6 × 9 in. Price $8.00.

This volume fills a long-standing need for a compendium which presents essential lighting theory and data in condensed and readable form. The new edition represents an extensive revision of the original 1947 publication, more than 75% of the material, according to the editors, being new or completely rewritten. Some 200 pp. of text have been added, and data have been revised in line with the best current values. Bibliographies at the ends of the sections have been extended to include material published as recently as September 1951.

The first part of the Handbook includes sections dealing with physics of light, light and vision, standards and nomenclature, measurement of light, color, light control, daylighting, light sources and lighting calculations. The second part is devoted to applications, with discussions of interior and exterior lighting, sports lighting, street and highway illumination, aviation and transportation lighting, miniature lamps, and photographic, reproduction, projection, television and radar screen lighting. A section on miscellaneous applications covers uses of ultraviolet and infrared energy. Illumination requirements of the various lighting fields and methods for fulfilling them are well covered.

The *Handbook* is, of course, designed primarily to serve the needs of the illuminating engineer. SMPTE members will find it a handy compilation of "time-tested" methods and techniques, although, as is natural in a volume covering the entire lighting field, material of direct interest to the SMPTE member receives rather brief treatment. The section on light sources includes two pages on the carbon arc, as well as tables giving performance characteristics of d-c and flame-type carbons. The discussion on lighting for motion picture photography includes descriptions and illustrations of incandescent and carbon-arc lamps commonly used for set lighting, tables showing beam characteristics, and figures giving spectral energy distributions. Some eight pages are devoted to picture projection lighting with paragraphs on brightness levels, screen surfaces, viewing conditions, projection booth design, and light output of typical carbon-arc systems. There are short discussions of television studio lighting and lighting of drive-in and motion picture theaters.

The concise summaries contained in the *Handbook* are supplemented through bibliographies appended to each section. An appendix contains conversion factors and equations, I.C.I. tristimulus computation data, and tables of selected ordinates. A detailed subject index, index tabs, and a complete table of contents for each section facilitate access to specific information. The paper used is of high quality, the print is larger and more legible than that usually found in handbooks, and illustrations and photographs have been provided with unusual generosity.

As an authoritative and convenient summary well provided with guides for further reading, the *IES Lighting Handbook* should find a place on the desk of every engineer required to deal with broad problems of lighting. The sections on light sources, measurements and calculations will be especially useful to the SMPTE member, though for detailed information on problems of motion picture studio, theater and projection lighting, it will still be necessary to consult the publications of the SMPTE.—*M. S. Wright*, National Carbon Research Laboratories, Cleveland, Ohio.

Basic Electron Tubes

By Donovan V. Geppert. Published (1951) by McGraw-Hill, 330 W. 42 St., New York 36. 332 pp. 257 illus. 6 × 9 in. Price $5.00.

As the title implies, this book deals with the principles of operation of well-known vacuum tubes.

Written as a text for undergraduates, it fulfills the requirement for lucidity by an understandable style and a novel arrangement of subject matter. Undoubtedly founded on the axiom that an interested student learns rapidly and well, the author has reversed the conventional order of presenting his subjects.

Instead of starting with a few abstract statements and a welter of mathematics, he presents first the physical nature of the easily recognized practical tube, giving qualitative theory in explanation. From this he goes to the electrical nature of the tube, presenting the characteristic curves and an illustrative circuit. The theory is often explained with the assistance of the rubber-membrane rolling-marble model, which is shown in a well-executed three-dimensional illustration.

By this time even the interested tyro has a good conception of the device and then the author launches into the mathematical analysis that must be a part of any mature treatment. This is given meaning by sample calculations of problems likely to be faced in practice. Both cgs and mks units are used and the relation between the two systems explained.

The tubes treated are indicated by the chapter headings: 1. High-vacuum and Gas Phototubes; 2. High-vacuum Thermionic Diodes; 3. High-vacuum Triodes; 4. Tetrodes and Pentodes; 5. Beam-power Tetrodes; 6. Cathode-ray Tubes; 7. Glow-discharge Tubes; 8. Thermionic Gas Diodes; 9. Thyratrons; 10. Mercury-pool Arc Rectifiers; and 11. Ignitrons.

A useful feature of the book is a summary of the practical consequences of altering tube parameters. For instance, in the case of the triode, nine numbered sentences give the alteration of electrical characteristics for stated alterations of the tube structure. This tends to establish fundamentals in the mind of the student or engineer and serves as a focal point for reference when memory fades.

Additional references and problems are to be found at the end of each chapter.

The book is the fourth in a series of fourteen on electrical and electronic engineering, for which the well-known and esteemed Dr. Frederick Emmons Terman is Consulting Editor. This fact accounts for the title and the absence of discussion of the microwave tube. This device is more often a part of the circuit than a separate entity and so is treated in another book of the series.

The book would appear to be useful to nearly all motion picture and television engineers as a convenient reference.—*Harry R. Lubcke*, Consulting Engineer, 2443 Creston Way, Hollywood 28, Calif.

Bases Techniques de la Television

By H. Delaby. *In French.* Published (1951) by Editions Eyrolles, 61, Blvd. Saint-Germain, Paris (V°). 340 pp. 273 illus. 6½ × 9¾ in. Paper bound. Price 2,200 fr. (approx. $6.30).

The principal interest of a reader of this *Journal* in a technical book in a foreign language lies in whether, having surmounted the difficulties of translation, the reader will obtain information on other methods and devices that cannot be obtained in his native language. This reviewer's interest was largely in the practical details of the controversial 819-line French television system and its operation in the same studio plant with a 625- or 455-line system. Unfortunately, this book, although excellent in its way, is not informative about such details.

With its companion volume by the same author *Principes Fondamentaux de Television*, to which frequent reference is made, this book serves as an adequate text for a course in television at what would be in the United States, college senior level. The general principles of video amplifiers, synchronizing generators, studio cameras, film cameras, transmitters, receivers and antennas are covered in varying degrees of detail. Studio control equipment rates 8 pp.; the receiver, 24 pp.; and the transmitting antenna, 54 pp.; to cite a few

examples of the somewhat strange balance between topics. This is perhaps an unfair criticism, since much material of importance, such as the whole subject of scanning generators, is apparently covered in the companion volume.

There are several general texts on television published in the United States which cover in more detail essentially everything included in this book. Actually, over half the references are to technical magazines and books in English.

The one section which contains information not available in *American* (as distinguished from English-language) texts is that on the television transmission of film. The use of flying-spot scanners with continuously-moving film, and the peculiar problems of 50-cycle power supplies are discussed in reasonable detail. From the references given, however, this reviewer had the impression that, if he had obtained a copy of the proceedings of the "Congres de Television" which was held at Paris in 1948, he would be in a better position to learn about French television methods than by a study of H. Delaby's book.—*S. W. Athey*, General Precision Laboratory, Inc., Pleasantville, N.Y.

Television Principles

By Robert B. Dome. Published (1951) by McGraw-Hill, 330 W. 42 St., New York 36. i-xii + 281 pp. + 9 pp. index. 170 illus. 6 × 9 in. Price $5.50.

The material for this book was taken from a series of lectures which formed one of the radio training courses for engineers of the General Electric Co.

The book covers all stages of television transmission and reception. There are chapters on scanning and reproduction, transmitting apparatus, antennas for transmission and reception, propagation and relays, RF input circuits and noise factors, IF amplifiers, picture second detector and the scanning system. The author has followed the television signal from the camera through the receiver.

Mathematical development of many principles is shown and practical problems using these principles are given. The design problems make use of many of the latest types of tubes.

Schematic circuits and diagrams are used and there are no pictures or diagrams of commercial installations or equipment. The book is about engineering rather than operations and is concise and to the point.

On the transmitting side Mr. Dome has lightly covered the operation of the different pickup tubes and antennas. He has paid particular attention to video frequency amplifiers and picture transmitters.

On the receiving end he has emphasized radio frequency input circuits, intermediate frequency amplifiers and scanning circuits. The chapter on RF input circuits includes the cascode amplifier and has material on noise factors for each circuit.

A miscellany chapter covers such things as d-c restoration, automatic gain control, overall fidelity and the author's own intercarrier sound system.

The book is an excellent work and is a welcome addition to the McGraw-Hill Television Series.—*Otis S. Freeman*, Asst. Chief Engineer, WPIX, 220 E. 42 St., New York 17.

Application of the Electronic Valve in Radio Receivers and Amplifiers (Vol. II)

By B. G. Dammers, J. Haantjes, J. Otte, and H. Van Suchtelen. Published (1951) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Press, Inc., 402 Lovett Blvd., Houston 6, Texas. i-xviii + 425 pp. + 6 pp. index. 343 illus. 6 × 9 in. Price $7.75, English ed.

This is the second volume of a trilogy being put out by the famous Philips of Eindhoven on the uses of tubes in receivers and amplifiers, principally the former. Volume I covered rf and if amplification, frequency changing, interference and distortion, and detection. The present volume is devoted to af voltage and power amplification and power supplies. That being the case, it is of considerable value to motion picture workers, even though it is primarily concerned with receivers.

The treatment is by no means superficial and is entirely applicable to amplifiers and power supplies for any purpose. Tube performance is analyzed mathe-

matically and graphically and design criteria given for standard circuits. An interesting section, not strictly within the purview of tubes is on design of af transformers.—*Richard H. Dorf*, Audio and TV Consultant, 255 W. 84 St., New York 24, N.Y.

Agfacolor Process, a Short Bibliography

Compiled by Alexis N. Vorontozoff (1951), 25 mimeographed pages, 8½ × 11 in. Available from the Author, 10 rue Mademoiselle, Paris. Price, $0.50 plus postage.

Mr. Vorontozoff has done a noteworthy job in compiling 236 references on the Agfacolor Process which he has published alphabetically according to author, with a cross-reference list according to subject. He has indicated also whether or not the reference has been consulted directly, the language of the original paper, references to abstracts of each paper published in other periodicals, availability of reprints, translations, etc. The bibliography covers all aspects of the Agfacolor Process, including numerous references applicable to the motion picture field.—*Lloyd E. Varden*, Pavelle Color, Inc., 533 W. 57 St., New York 19, N.Y.

Transmitting Valves

By J. P. Heyboer and P. Zijlstra. Published (1951) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Press Inc., 402 Lovett Blvd., Houston 6, Texas. i-xii + 281 pp. + 2 pp. index. 256 illus. 6 × 9 in. Price $6.25, English ed.

This volume is Book VII of the fast-growing Philips library. It is concerned with the characteristics of transmitting tubes—pentodes, tetrodes, and triodes in which transit-time effects are negligible—and the circuits in which they are used. Chapters give thorough mathematical design treatments of tube construction, rf power amplifiers, oscillators and frequency multipliers, as well as some data on special uses such as vhf feedback circuits. One of the appendixes contains a table of technical data on Philips transmitting tubes. As with the receiver book from Philips (reviewed above), the translation is excellent, the language clear and concise.—*Richard H. Dorf*, Audio and TV Consultant, 255 W. 84 St., New York 24, N.Y.

Positions Wanted

Photographic Chemist: 3 yr. experience black-and-white and color film laboratory practice and quality control. Familiar with all commercial color processes and sensitometry. Have conducted research in new processing methods. Position desired in research or development on new products and processes. Will relocate. Write M-52, c/o Lichtig, 3758 Tenth Ave., New York 34, N.Y.

Production, TV or Motion Picture: NYU BA in motion picture and TV production; participated in productions as director and unit mgr; experience as motion picture sensitometrist; at present motion picture negative assembler and cutter; worked swing shift while attending college; licensed 35mm projectionist; single, 29, veteran, resumé on request; go anywhere. Harold Bernard, 560 Eastern Pkwy, Brooklyn 25, N.Y.

Sound mixer and transmission engineer: 5 yr experience 35mm magnetic and optical 16mm optical and disc recording systems. As mixer has experience stage recording and re-recording; in transmission has installed a recording channel complete from design to operation, also maintenance. Will accept position any geographic location. Write L-30, c/o Fifer, 143 Church St., Phoenixville, Pa.

Motion pictures in color depend on the engineers' knowledge of the "Principles of Color Sensitometry." A 72-page article bearing that title and prepared by the Color Sensitometry Committee appeared in the *Journal* for June 1950. Attractive reprint copies may be purchased for $1.00.

Meetings

72nd Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

Society of Photographic Engineers, Photographic Instrumentation Symposium, June 4–5, Naval Ordnance Laboratory, White Oak, Md.

American Institute of Electrical Engineers, Summer General Meeting, June 23–27, Hotel Nicollet, Minneapolis, Minn.

American Physical Society, June 30–July 3, Denver, Colo.

National Audio-Visual Association, Convention and Trade Show, Aug. 2–5, Hotel Sherman, Chicago, Ill.

University Film Producers Association, Annual Meeting, Aug. 11–15, Syracuse University, Syracuse, N. Y.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

American Standards Association, Third National Standardization Conference, Sept. 8–10, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society, National Technical Conference, Sept. 8–12, Edgewater Beach Hotel, Chicago, Ill.

Biological Photographic Association, Annual Meeting, Sept. 10–12, Hotel New Yorker, New York

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

Six American Standards have been added to the Motion Picture Set of 60 which the Society has had available for sale. To holders of the present set the Society has made available the seven new standards: PH22.11-1952, PH22.24-1952, PH22.73-1951, PH22.74-1951, PH22.76-1951, PH22.77-1952 and PH22.82-1951. The price is $1 plus 3% sales tax on deliveries in New York City.

The new set of 67 standards in a heavy three-post binder with an index is available at $14.50 plus 3% sales tax on deliveries in New York City; foreign postage is $.50 extra.

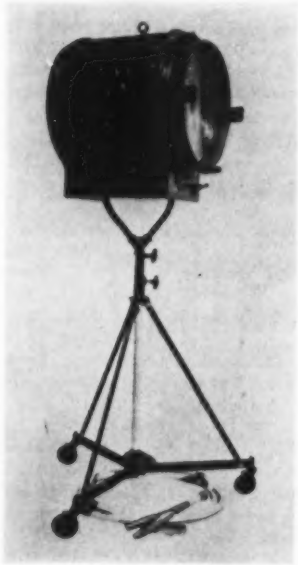
All standards **in sets only** are available from Society Headquarters. Single copies of any particular standard must be ordered from the American Standards Association, 70 E. 45th St., New York 17, N.Y.

Back issues of the Journal available: A set of Journals from January 1945 through 1951 is available at $15.00 plus packing and carrying costs from Richard W. Maedler, 32–52 — 46 St., Long Island City 3, N.Y.

Back issues of the Journal available: Don Canady, 5125 Myerdale Drive, R.R. 15, Cincinnati 36, Ohio, desires to dispose of a complete set, in excellent condition, from January 1930 to date, plus one issue of September 1928. Anyone interested in acquiring the complete set should communicate directly with Mr. Canady.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



The Tener has been announced as a 25th Anniversary Topper by Mole-Richardson Co., 937 N. Sycamore Ave., Hollywood 38, Calif. This 10,000-w lamp, Type 416, is described with these specifications: constructed of sheet metal with interlocking channels for ventilation; condenser, special 20-in. Fresnel, 15° to 40° divergence; mirror, Alzak aluminum and completely adjustable; socket, Mogul Bipost; globe, 10,000-w G96 Mogul Bipost; focusing by handle on front or back; cable, 25-ft loom-covered with stage plug and furnished separate from lamp for attachment with pin plugs; switch, 100-amp; weight, 117-lb head, 16-lb cable and 37-lb pedestal. Accessories, sold separately but also described in a Mole-Richardson brochure, are: barn door, diffuser frame and shutter.

Fundamentals of Magnetic Recording is a 50-page handbook covering the subject chiefly under these headings: magnetic recording method, magnetic relations, bias, erasing, output, uniformity of output, frequency response, distortion and noise, modulation noise, tape construction, head wear, printing, splicing, selecting a tape recorder, and maintenance. Written by C. J. LeBel, Vice-President of Audio Devices, it is available at no charge upon a written request to Audio Devices, Inc., 444 Madison Ave., New York 22, N.Y.

Correction and Amplification: In the description of a lightweight sound-proof blimp, p. 274 of the March 1952 *Journal*, the manufacturer of the Arriflex camera was erroneously noted. The Arriflex is made in Germany by Arnold & Richter K.G., 89 Tuerkenstrasse, Munich, Western Zone; and the sole agents in North America are Kling Photo Supply Corp., 235 Fourth Ave., New York 3, N.Y.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal*.

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